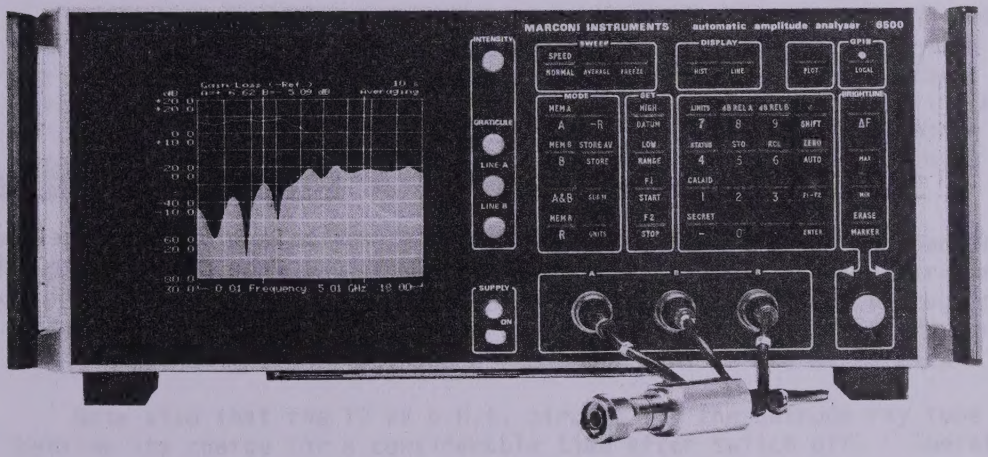
Operating Manual
H 6500
Vol. 1

Automatic Amplitude Analyser

6500

Including Option 6500-001 (GPIB Interface)



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PRELIMINARIES

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HAZARD WARNING SYMBOLS

The following symbols appear on the equipment

Symbol	Type of hazard	Reference in manual
⚠	Static sensitive device	Page (iv)
⚠	Dangerous voltages present	Page (iii)
⚠	Supply voltage	Chap. 2, page 2

NOTES AND CAUTIONS

ELECTRICAL SAFETY PRECAUTIONS

This equipment is protected in accordance with IEC Safety Class 1. It has been designed and tested according to IEC Publication 348, 'Safety Requirements for Electronic Measuring Apparatus', and has been supplied in a safe condition. The following precautions must be observed by the user to ensure safe operation and to retain the equipment in a safe condition.

Defects and abnormal stresses

Whenever it is likely that protection has been impaired, for example as a result of damage caused by severe conditions of transport or storage, the equipment shall be made inoperative and be secured against any unintended operation.

Removal of covers

Removal of the covers is likely to expose live parts although reasonable precautions have been taken in the design of the equipment to shield such parts. The equipment shall be disconnected from the supply before carrying out any adjustment, replacement or maintenance and repair during which the equipment shall be opened. If any adjustment, maintenance or repair under voltage is inevitable it shall only be carried out by a skilled person who is aware of the hazard involved.

Note that capacitors inside the equipment may still be charged when the equipment has been disconnected from the supply. Before carrying out any work inside the equipment, capacitors connected to high voltage points should be discharged; to discharge mains filter capacitors, if fitted, short together the L (live) and N (neutral) pins of the mains plug.

Note also that the 12 kV e.h.t. circuit for the cathode ray tube retains its charge for a considerable time after switch off. Therefore before any handling is carried out in the vicinity of the cathode ray tube or e.h.t. unit it is essential that the supply is disconnected from the instrument and the final anode lead is shorted to the chassis several times immediately after unplugging. The residual charge on the c.r.t. itself must also be removed by shorting the anode connection to earth.

Mains plug

The mains plug shall only be inserted in a socket outlet provided with a protective earth contact. The protective action shall not be negated by the use of an extension lead without protective conductor. Any interruption of the protective conductor inside or outside the equipment is likely to make the equipment dangerous.

Primary fuses

Note that there is a supply fuse in both the live and neutral wires of the supply lead. If only one of these fuses should rupture, certain parts of the equipment could remain at supply potential.

To provide protection against breakdown of the supply lead, its connectors, and filter where fitted, an external supply fuse (e.g.fitted in the connecting plug) should be used in the live lead. The fuse should have a continuous rating not exceeding 6A.

Make sure that only fuses with the required rated current and of the specified type are used for replacement. The use of mended fuses and the short-circuiting of fuse holders shall be avoided.

Secondary fuses

Each secondary winding of transformer T1 (with the exception of +5 V and +12 V supply lines, adequately protected by the primary fuses F1 and F2) is fused with a 250 mA, A-T (250 milliamp time lag) fuse to provide added safety. These are situated on the secondary tag board within the instrument and can be accessed by removing the lower cover.

CAUTION: STATIC SENSITIVE COMPONENTS

Components identified with the symbol ⚠ on the circuit diagrams and/or parts lists are static sensitive devices. The presence of such devices is also indicated in the equipment by orange discs, flags or labels bearing the same symbol. Certain handling precautions must be observed to prevent these components being permanently damaged by static charges or fast surges.

(1) If a printed board containing static sensitive components (as indicated by a warning disc or flag) is removed, it must be temporarily stored in a conductive plastic bag.

(2) If a static sensitive component is to be removed or replaced the following anti-static equipment must be used.

A work bench with an earthed conductive surface.

Metallic tools earthed either permanently or by repeated discharges.

A low-voltage earthed soldering iron.

An earthed wrist strap and a conductive earthed seat cover for the operator, whose outer clothing must not be of man-made fibre.

(3) As a general precaution, avoid touching the leads of a static sensitive component. When handling a new one, leave it in its conducting mount until it is required for use.

(4) If using a freezer aerosol in fault finding, take care not to spray programmable ICs as this may affect their contents.

WARNING: HANDLING HAZARDS

This equipment is formed from metal pressings and, although every endeavour has been made to remove sharp points and edges, care should be taken, particularly when servicing the equipment, to avoid minor cuts.

When exposing or handling the cathode ray tube care must be taken to prevent implosion and possible scattering of glass fragments. Handling should only be carried out by experienced personnel and the use of safety mask and gloves is recommended.
A defective tube should be disposed of in a safe manner by an authorized waste contractor.

WARNING: TOXIC HAZARD

Many of the electronic components used in this equipment employ resins and other chemicals which give off toxic fumes on incineration. Appropriate precautions should therefore be taken in the disposal of these items.

Chapter 1

GENERAL INFORMATION

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FEATURES

1. The 6500 Automatic Amplitude Analyser provides accurate scalar measurements quickly and efficiently. All relevant data is presented on the c.r.t. display and the user is able to control any external sweeper utilizing an external ramp. (See Chapter 3, Operation).

2. Microprocessor control ensures flexibility, simplicity of use and provides many useful facilities. Three input channels A, B and R are available. The A & B channels are referred to as measurement channels and the R channel as the reference. If required the response on the R channel may be subtracted from channels A and/or B. This enables measurements to be made independent of sweeper frequency response and level variations. Three memories are provided to allow normalization or comparisions to be made between current and stored responses.

3. Measurements over a frequency range up to 126 GHz are possible depending on the detectors used. The detectors 6511 and 6512 allow measurements over the range 10 MHz to 18 GHz to be made.

4. The 'Brightline' allows spot measurements to be made independent of DATUM and RANGE. This information together with the frequency of the spot measurement is displayed in digital form on the c.r.t. to .01 dB resolution.

5. Display sensitivity (RANGE) can be set from 0.1 to 10.9 dB(m) per division and the DATUM in the range ±99.9 dB(m); both these parameters can be set independently on each channel. Alternatively, the AUTO facility will automatically select the best DATUM and RANGE to fit the trace(s) on the screen, relieving the user of the task of setting them manually. In addition, the required sweep width can be set anywhere within the sweepers range to a resolution of 10 MHz.

6. A facility for checking responses to specification is provided by the limit facility. HIGH and LOW limits may be individually entered for the 'A' and 'B' channels. If any limit is exceeded during a sweep a warning message is generated on the alphanumeric display. Up to 9 sets of display parameters and limits may be stored and recalled thus allowing fast testing of devices to different specifications in different frequency bands.

7. The Sweep can be stopped to permit photography or plotting. The PLOT facility uses an X-Y plotter and can write the traces and in addition amplitude and frequency information.

8. All the 6500 keyboard functions can also be programmed by the general purpose interface bus (GPIB) if the option 6500-001 is fitted. This option also allows many additional facilities to optimise its use in an automatic test equipment system (ATE).

Display Characteristics

9. The front panel provides an integral green phosphor c.r.t. for display of all measurement information. The main display components are illustrated in Fig.1 below.

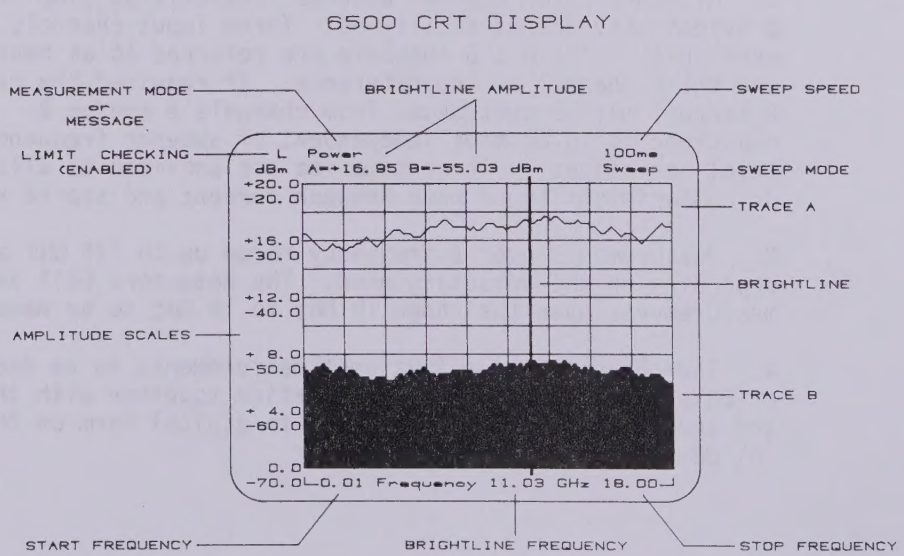


Fig.1 Display components

10. Alphanumerics. The alphanumeric display provides a 40 x 25 character format for display of measurement parameters, user prompts and other messages. The top line of the display is reserved for titling the measurement:

e.g. Power
dB Relative
Gain/Loss (-Ref) (-A,R)

and for displaying the selected nominal sweep speed. If the GPIB option (6500-001) is fitted, this line can be replaced with any title up to 28 characters long.

11. Graticule. The graticule lines on the frequency (X) axis are placed by the microprocessor at calculated intervals in order to provide standard frequency divisions in multiples of 1,2 or 5. These will vary depending on the actual sweep width selected. On sweep widths of 100 MHz or less these are not produced. On the amplitude (Y) axis there are ten fixed divisions which can be set to cover from 0.1 to 10.9 dB(m) per division.

12. Line displays, A and B. There are two display memories, A and B, each containing 422 horizontal measurement points with a vertical resolution of 256 points. These are used for display purposes only and do not limit the resolution available for measurements. Each channel can be displayed in 'Line' or 'Histogram' form, although the R channel will be displayed in the same form as the A channel. When a sweep is started, the relevant channels will be switched on and cleared. On all subsequent sweeps each point will be updated as the measurement is made, thus providing a flicker-free display.

13. Brightline. The Brightline is a single moveable vertical line, which can be placed anywhere within the graticule. It is used for spot measurement purposes and the information relating to the amplitudes and its position on the frequency axis is displayed above and below the graticule respectively - see Fig.1.

Up to 8 markers can be placed on the screen using the Brightline. These are fixed in position and are for visual reference. When PLOT facility is enabled these appear as tick marks on the hard copy.

SPECIFICATION

	Characteristic	Performance
14.	Frequency range:	0-126 GHz (dependent on detector).
15.	Dynamic range (All channels)	
	Normal mode:	66 dB (+16 dBm to -50 dBm).
	Average mode:	71 dB (+16 dBm to -55 dBm).
16.	Resolution (Brightline)	
	Frequency:	Digital readout to 10 MHz.
	Amplitude:	Digital readout to 0.01 dB(m).
17.	Frequency Linearity:	Dependent on linearity of sweeper, See Ramp output linearity.
18.	Markers:	Up to 8 on-screen markers with 10 MHz resolution.
19.	Front panel selectable parameters	
	Range:	0.1 to 10.9 dB(m) division; 0.1 dB(m) increments.
	Datum:	±99.9 dB(m); 0.1 dB(m) increments. Above parameters individually selectable on A,B and R channels.
	High/Low Limits:	±99.99 dB(m) individually selectable on A and B channels.
	F1,F2 (Sweep range):	Selectable in range 0-126 GHz; (10 MHz resolution).
	Start,Stop (Selected range):	Selectable within range F1-F2; (10 MHz resolution).
	ΔF:	Selectable symmetrically within range F1-F2; Centre Frequency is Brightline position. (10 MHz Resolution).
	Display format:	Line or histogram independently on A, B channels.
	Sweep speed:	70 ms to 20 s nominal (10 alternative speeds).

Characteristics	Performance
X-Y plotter functions:	Set pen bottom left. Set pen top right. Set pen to origin. Draw axes. Label axes. Plot. Set pen lift Set plot speed (9 alternatives).
20. Ramp output	
Output 1 (Fixed range)	
Range:	0 - 10V ± 10 mV.
Linearity:	±5 mV.
Resolution:	4096 points.
Output 2 (Variable)	
Range:	Adjustable from 1 - 20 V (approx) using coarse and fine rear panel controls.
Offset:	Bottom of range = 0 V ±10% of range (above).
Linearity:	±0.25 %.
Resolution:	4096 points.
21. Plotter output	
X output:	See Ramp output 1: BNC socket.
Y output:	0 - 10 V ±50 mV: BNC socket.
Z output:	Open collector drive: BNC socket selectable high/low impedance for pen up/down.
22. Channel memories:	At any time when valid data is available on the screen, the trace may be stored in any of the three memories. New data may be averaged with data already present. When invoked:-
	A memory is subtracted from A trace. B memory is subtracted from B trace. R memory is subtracted from A and/or B trace, as selected. Recall is available on all memories.

	Characteristics	Performance
23.	CRT	
	Dimensions:	105 mm x 135 mm used screen area.
	Phosphor:	P31 green.
24.	Power requirements	
	Voltage:	AC supply. Voltage ranges (switchable) 105 - 120 V or 210 - 250 V.
	Frequency:	50 to 60 Hz.
	Consumption:	120 VA maximum.
25.	Safety:	Meets IEC 348.
26.	Radio Frequency interference:	Conforms with the requirements of EEC Directive 76/889 as to limits of r.f. interference.
27.	Temperature range	
	Operational:	0 - 50 ^{o}C.
	Full specification:	10^{o} - 35 ^{o}C.
28.	Conditions of storage and transport	
	Temperature:	-40 ^{o}C to +70 ^{o}C.
	Humidity:	95 % relative at 35 ^{o}C.
29.	Dimensions and weight (approximately)	With handles and feet.
	Height:	192 mm (7.5 in).
	Width:	427 mm (16.8 in).
	Depth:	533 mm (21.2 in).
	Weight:	15.7 kg (34.5 lb).
30.	Remote programming	
	GPIB interface with Compatibility module (6500-001):	A GPIB interface is available as an optional accessory and can be fitted by the user.

ACCESSORIES

Supplied accessories

		Part No.
31.	AC supply lead	23424-158H
	Operating manual	H 6500 (Vol. 1)

Optional accessories

32.	Detectors :	6511 0.01 - 18 GHz Type N male connector	
		6512 0.01 - 18 GHz Type APC-7 connector	
		6514 26.5 - 40 GHz Flange face UG 399/U*	
		* Consult factory for availability.	
	Cables :	6510 Series detector extender cable, 5 m	3964-004
		Adaptor cable for other detectors	3964-006
		GPIB cable, 1 m	43129-189U
		Interface cable to HP 8620C	3964-003
		BNC-BNC cable, 1.5m	43126-012S
	Measurement accessories :	High directivity coupler, 1-18 GHz	2200-332
		Power divider, 2-18 GHz	2200-335
		Microwave bridge set, 2-18 GHz, 36 dB directivity	2200-327
	Mechanical accessories :	Camera mount	3964-239
		Camera hood	46883-267B
		Rack mounting kit, 19 in.	3964-400
	Servicing/Maintenance aids :	Service manual	H 6500 (Vol. 2)
		Diagnostic ROM	3964-258
	GPIB module (Option 001)		3964-300

DETECTOR SPECIFICATIONS

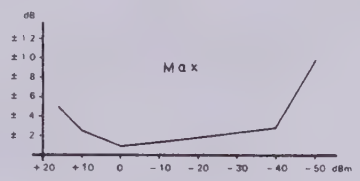
33. Performance specifications for detectors at present available are given below. Additional information will be available as the range of detectors is expanded to suit user requirements.

34. 6511 Detector

Frequency range : 0.01 to 18 GHz.

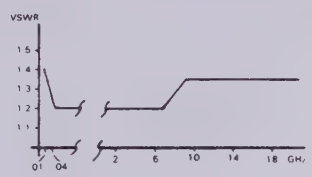
Dynamic range : -55 dBm to +16 dBm.

Power accuracy at 50 MHz at 23°C ±4°C (excluding errors due to Return loss, Flatness and Source harmonics).



Maximum input power : +26 dBm.

VSWR :



Detector tracking : ±0.5 dB variation 0.01 to 18.0 GHz.

Detector flatness : ±0.5 dB at -10 dBm input power.

Connector : Precision type N.

35. 6512 Detector

This detector has an identical specification to that of the 6511; the only difference is that the 6512 is fitted with an APC-7 connector.

Chapter 2

INSTALLATION

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1 Unpacking and repacking
3 Mounting arrangements
4 Connecting to supply
6 Safety testing
7 GPIB interface
8 Rack mounting

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UNPACKING AND REPACKING

1. Retain the packing materials and the packing instruction note (if included) in case it is necessary to reship the instrument.

2. If the instrument is to be returned for servicing attach a label indicating the service required, type or model number (on rear label), serial number and your return address. Pack the instrument in accordance with the general instructions below or with the more detailed information in the packing instruction note.

(1) Place a pad in the bottom of the container.

(2) Place pads in the front and rear ends of the container with the plywood load spreader(s) facing inwards.

(3) Put the polythene cover over the instrument and place it in the container with the front handles and rear projections (where applicable) against the plywood load spreaders.

(4) Place pads in the two sides of the container with cushioning facing inwards.

(5) Place the top pad in position.

(6) Wrap the container in waterproof paper and secure with adhesive tape.

(7) Mark the package FRAGILE to encourage careful handling.

Note....

If the original container or materials are not available, use a strong double-wall carton packed with a 7 to 10 cm layer of shock absorbing material around all sides of the instrument to hold it firmly. Protect the front panel controls with a plywood or cardboard load spreader; if the rear panel has guard plates or other projections a rear load spreader is also advisable.

MOUNTING ARRANGEMENTS

3. Excessive temperatures may affect the instruments performance; therefore, completely remove the plastic cover, if one is supplied over the case. Ensure that the fan air vent and other ventilation holes are not obstructed otherwise the maximum temperature specification is reduced resulting in imperfect operation. Avoid standing the instrument or associated detectors in the vicinity of large transformers or other possible magnetic fields or where X rays are present. If the source of such fields cannot be isolated Mumetal shields should be used to provide the necessary screening.

CONNECTING TO SUPPLY

4. Before connecting the instrument to the a.c. supply check the position of the voltage selector switch. The range selected can be seen on the side of the switch protection plate situated on the rear panel.

The instrument is normally dispatched selected to the 210-250V range. To select the 105-120V range remove the protection plate, switch ranges and change the value of the a.c. supply fuses to that shown below, reverse and refit the protection plate.

115 V range	1.25 A-T (1.25 amp time lag)
230 V range	600 mA -T (600 mA time lag)

Fuses are 20 mm x 5 mm cartridge type.

5. The supplied a.c. supply cable is fitted at one end with a female plug which mates with the a.c. connector at the rear of the instrument. When fitting a supply plug ensure that conductors are connected as follows:-

Earth	-	Green/Yellow
Neutral	-	Blue
Live	-	Brown

Any interruption of the earth conductor is liable to make the equipment dangerous.

When attaching the mains lead to a non-soldered plug it is recommended that the tinned ends of the lead are first cut off owing to the danger of cold flow resulting in intermittent connections.

SAFETY TESTING

6. Where safety tests on the mains input circuit are required, the following procedures can be applied. These comply with BS 4743 and IEC Publication 348. Tests are to be carried out as follows and in the order given, under ambient conditions, to ensure that mains input circuit components and wiring (including earthing) are safe.

(1) Earth lead continuity test from any part of the metal frame to the bared end of the flexible lead for the earth pin of the user's mains plug. Preferably a heavy current (about 25 A) should be applied for not more than 5 seconds.

Test limit: not greater than 0.5 ohm.

(2) 500 V d.c. insulation test from the mains circuit to earth.

Test limit: not less than 2 M ohm.

GPIB INTERFACE (option 001)

7. The GPIB interface is an optional accessory and can easily be fitted by the user as follows:-

(1) Switch the instrument off and disconnect from the supply.

(2) Remove and discard the rectangular cover plate from the left hand side of the rear panel, also remove the instruments bottom cover. Insert the cable and p.c.b. through the rear panel such that the GPIB connector is on the left hand side. Using the two retaining screws from the cover plate, secure the GPIB assembly to the rear panel.

(3) Remove the 15 way bulkhead connector (PL3) to allow access to the GPIB interface connector (SK14) on the motherboard (AM01). Feed the interface cable through the gap in the bulkhead metalwork as shown in Fig.1a and connect the interface plug to SK14 observing correct polarity. Re-connect PL3 to the bulkhead socket SK3.

(4) Add the two supplied labels to the rear panel to identify the GPIB connector and address switch as shown in Fig.1b. Replace the bottom cover.

The instrument is now ready for GPIB operation.

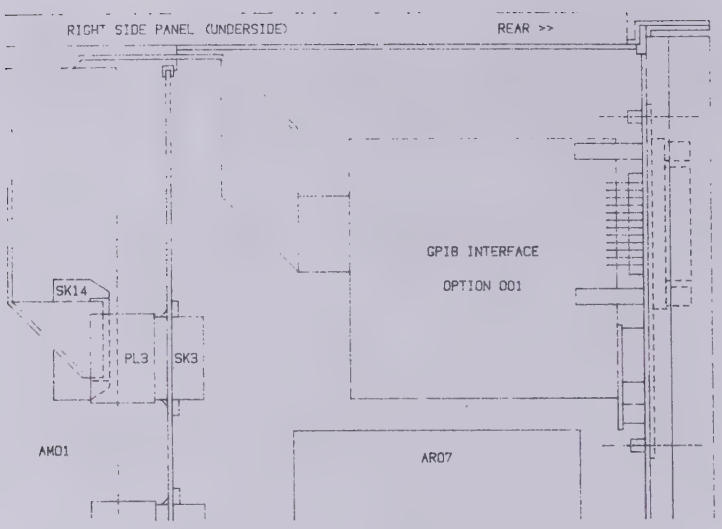

FIG.1a 6500 GPIB INTERFACE OPTION INSTALLATION

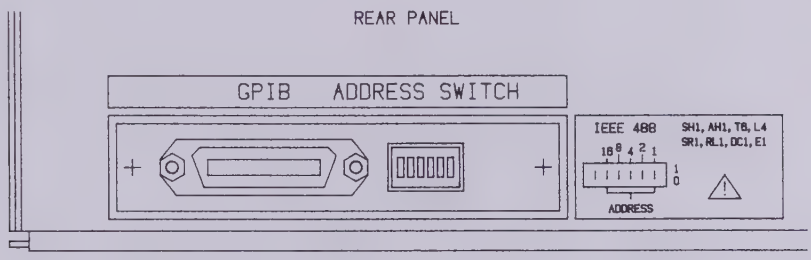

FIG.1b 6500 GPIB INTERFACE OPTION LABEL POSITIONING

Fig.1 Fitting the GPIB interface

RACK MOUNTING

8. The instrument may be mounted in a standard 19 inch rack using the kit Part No.3964-400 available as an optional accessory. Fitting instructions are as follows:-

(1) Disconnect the mains supply.

(2) Remove both top and bottom outer covers, detach and discard front and rear feet on bottom cover.

(3) Fit rack brackets in front handles on side trim recesses using M 4 x 16 pan head screws and washers, finally refit top and bottom covers.

Chapter 3-1

OPERATION

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PREPARATION FOR USE

1. Providing the instrument is properly adjusted for a.c. supply voltage and is connected to an outlet socket with the correct fuses fitted, the instrument can be switched on.

2. A self test operation which checks the instrument's memory is applied. Should the instrument fail the self test, LOCAL and SHIFT l.e.d.s will flash alternately and a message descriptive of the fault together with the c.r.t. test pattern will remain on the screen (see Fig. 1).

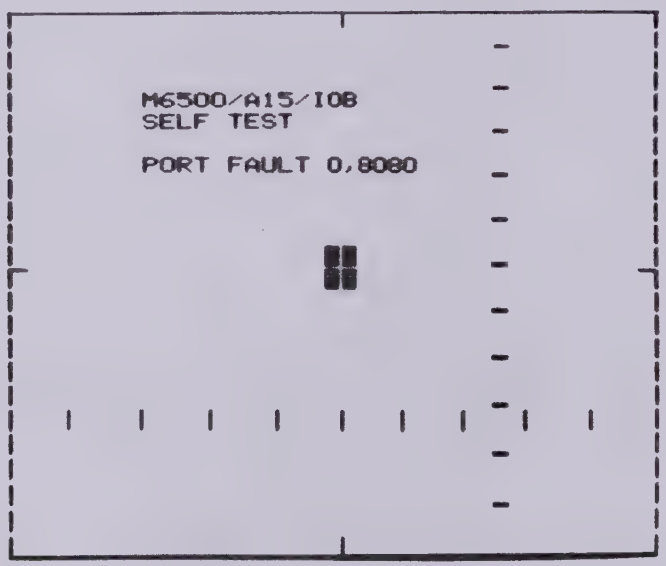


Fig.1 Test pattern display and self test fault indication.

A failure can be simulated by holding down any key other than MARKER as power is applied. If the instrument is functioning correctly the LOCAL l.e.d. will remain on, the SHIFT l.e.d. OFF and a display of power on channel A will be shown.

Note ...

If the power-on mode does not initiate the correct display or if the GPIB/LOCAL l.e.d. remains off; switch the power off, wait 10 seconds and repeat the switch on procedure.

3. To remove build up of small d.c. voltages, a zero operation must be performed before any measurements are made and this must be carried out with all required probes connected and the r.f.switched off.
(See Miscellaneous secondary functions - ZERO key, Chap. 3-1, paras. 35 to 38, for details).

4. The 6500 can control any microwave sweeper capable of accepting an external ramp control. Two voltage ramps are available; a fixed 0 to 10 V and an adjustable 0 to 20 V, either may be connected via the rear panel BNC terminations. In some cases special terminations, connectors or cables are necessary to couple the 6500 to the sweeper; these can be supplied as optional accessories complete with fitting instructions.

5. Once this connection has been made the 6500 should be initialized to the sweeper by entering the F1 and F2 settings on the 6500 (the F1 and F2 frequencies are those obtained from the sweeper when the external ramp is at its minimum and maximum respectively). To facilitate this procedure, the ramp is moved to the bottom and top of its range when the prompts for setting F1 and F2 appear on the 6500 screen. This allows the use of a frequency counter so that measured frequencies can be entered. This is especially useful when frequencies generated under external ramp control can be affected by the front panel controls of the sweeper.

6. In addition to the frequency control one further connection may be necessary. If a multiband sweeper is being used then it is desirable to pause the sweep when the bandswitch points occur to avoid errors due to the delay between one oscillator stopping and the next starting. This can be accomplished by connecting the SYNC input on the rear panel of the 6500 to the appropriate blanking output of the sweeper. A single BNC lead is required. Fig.2 shows the connections to a typical sweeper and a counter. The titles of input and outputs on particular sweepers are listed following this figure.

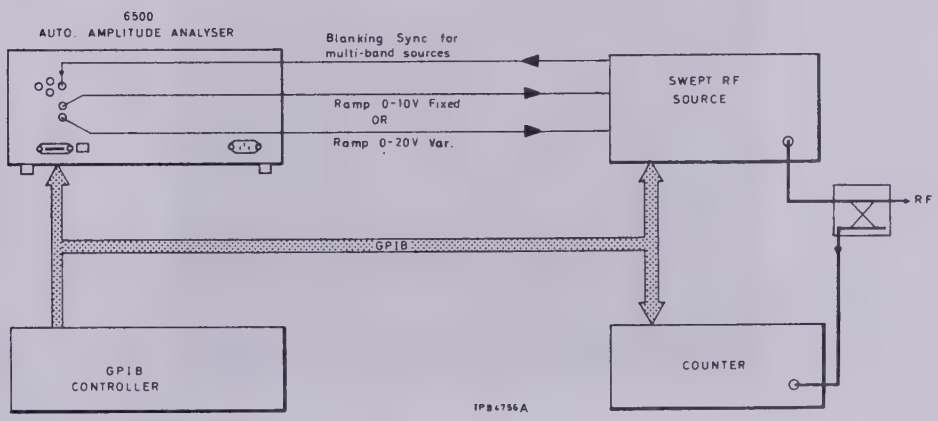


Fig. 2 Connections to Swept RF Source and Frequency Counter

RF Source		Comments		
Manuf.	Type	Ramp Input	Rear Panel	Front Panel
Marconi Instruments	6700 Series	0-10V	Use Ext.Sweep input.	Set Sweep Function to Ext/M1.Sweep M1 to end of band.
"	6600A/1 "	0-20V approx.	-	Use EXT Sweep input. Set Sweep/CW to EXT.
"	6158A & 6150 Series	0-10V	Use Sweep Input	Set Function to SWP. (Not CW or AM)
Hewlett Packard	8690 Series	0-20V	-	Use EXT FM Input Note: Need 35V for fullband sweep.
"	8620C Series	0-10V	Use Pin 28 and 43(ground) on Socket J2 or MI Interface cable Part No. 3964-003. Use Sync on multiband plug-ins. GPIB (HP-IB) Option 011 if fitted.	Set Sweep Mode to EXT. Note:Under GPIB better to use Start/Stop Marker sweep with markers set by counter Note also no local lockout of HP8620C Front Panel Controls.
"	8350A Series	0-10V	GPIB (HP-IB) Use Blanking Sync on Multi-band plug-ins.	Set Sweep to EXT. Connect ramp to Sweep input. Note: Sweep input and output are same BNC socket Note: Under GPIB Control set F1 and F2 on 6500 and then put into FREEZE mode. Using Brightline at start adjust 8350A start frequency for desired reading on counter. Repeat for Stop Frequency. This method locks out 8350A. Controls and offset and gain errors of 6500 ramp are calibrated out.
Wiltron	610D Series	0-20V Set 0 to 9.75V	Open link BC. Use terminals B & D. Use Blanking Output during Bandswitch for Sync. (B is signal, D is ground).	Set Freq.Program to External. Note: If fitted with GPIB (option 16) use SYNTH mode described in para 47 onwards, or details of a simple modification can be provided on request.
"	6600 & 6600A Series	0-10V	Use BNC EXT Sweep Input GPIB (Opt.3)	Set EXT Sweep Note: See Under 8350A for GPIB marker sweep.

FRONT PANEL CONTROLS

7. (1) SUPPLY

Applies the a.c. supply voltage in both manual and remote control operation.

(2) INTENSITY

Adjusts the overall brightness of the c.r.t. display. The three associated controls, GRATICULE, LINE A and LINE B, allow the relative brightness of the graticule and the two channel displays to be independently controlled.

(3) BRIGHTLINE rotary control

The 'spin wheel' at the bottom right-hand side of the instrument provides manual control over the position of the brightline. At switch on this is automatically positioned on the left of the screen. There is no manual limit on the spin wheel.

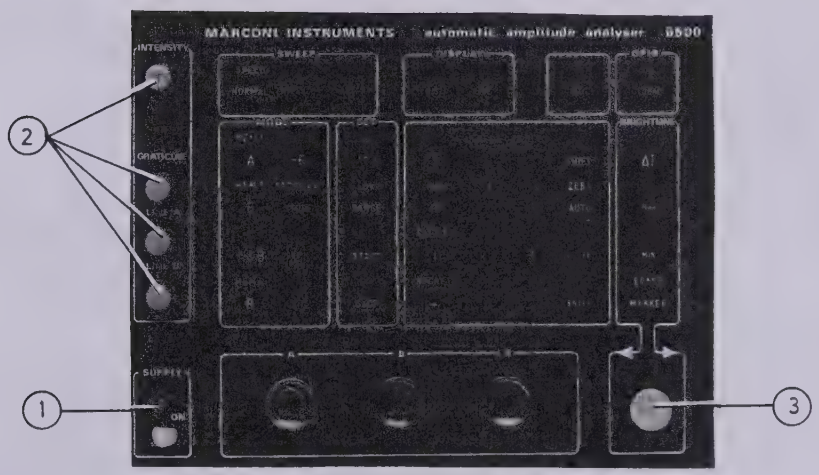


Fig.3 Front Panel Controls

REAR PANEL CONTROLS

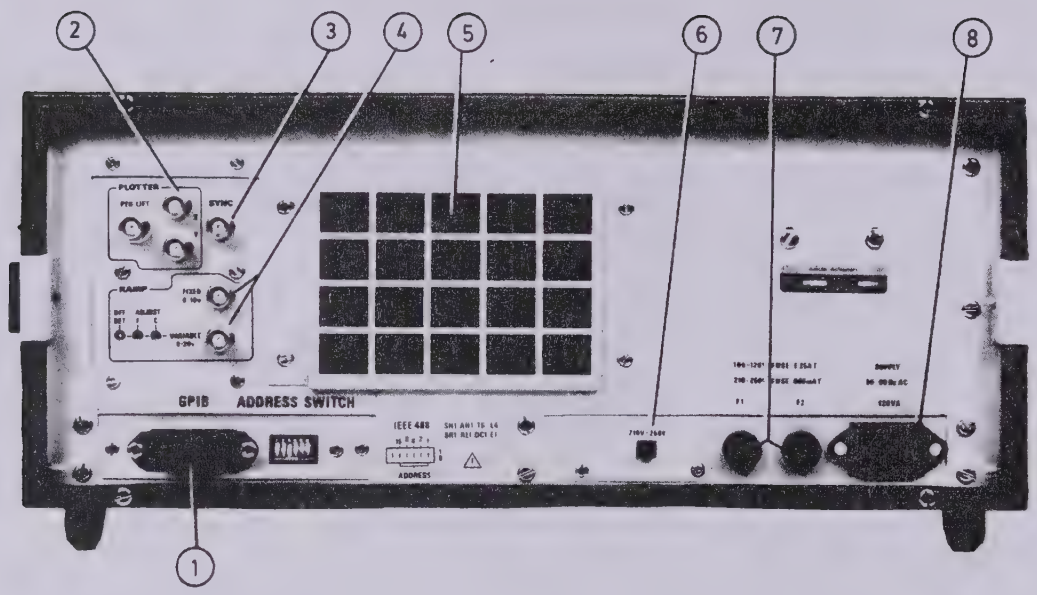


Fig.4 Rear panel controls

8. (1) GPIB Interface

This optional accessory allows remote control of the instrument and accepts the standard 24-way IEEE GPIB connector. An adaptor, Code No.46883-408K is available for IEC 625 systems.

(2) PLOTTER

By connecting the X,Y and PEN LIFT outputs to a standard X-Y recorder a plot of the current traces plus graticule and scaling information can be provided. The PEN LIFT output is usually closed circuit for pen down and open circuit for pen up; This can, however, be reversed by the user if required by following screen prompts when PLOT key is pressed.

(3) SYNC

When this socket is connected to the appropriate socket of a multiband sweeper, correct operation at the bandswitch points is ensured. A High level (3 to 5V) or Low level (- 3 to - 5V) from the sweeper will pause the 6500 sweep while this sync level is maintained. When the voltage at this input returns to 0V the sweep will continue. Using this input it is possible to stop the 6500 sweep for up to 600 ms at any one measurement point.

(4) RAMP

(i) FIXED 0 - 10 V. This output provides the necessary control voltage to drive the sweeper. When sweeping from F1 to F2 as set on the 6500 this output will sweep from 0 to 10 V. When different start and stop frequencies have been selected this output will sweep across correspondingly different voltages.

(ii) VARIABLE 0 - 20 V. The variable output provides the same function as the fixed output, but is for connection to sweepers which require a different drive level. The maximum range of this ramp output voltage can be adjusted using the coarse (c) and fine(f) screwdriver adjustment controls. The starting point of this ramp output can be adjusted by the offset screwdriver control between ±10% of its maximum setting. This operation may need more than one iteration.

(5) Fan air vent

Forced air cooling is used to maintain the required operating temperature within the instrument, therefore allow at least 75 mm (3 in) clearance at the rear of the instrument and ensure that the air vents are not obstructed. The cooling fan requires no maintenance although the air filter should be cleaned at regular service intervals.

(6) AC supply locking plate

The instrument is normally despatched with the plate locking the supply selector switch to the 210-250 V position. To change to 105 - 120 V operation, remove the locking plate, adjust the switch, reverse the locking plate and refit.

(7) AC supply Fuses

Supply input fuses are rated at 600 mA-T for 210-250 V operation or 1.25 A-T for 105-120 V operation.

Note: The instrument employs double fusing, and should the fuse in the neutral line rupture certain areas in the instrument may remain at mains potential.

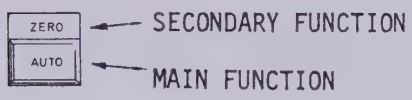
(8) AC supply input

Accepts a.c. supply input of 50-60 Hz; the earth pin is internally connected to chassis.

OPERATING PROCEDURE

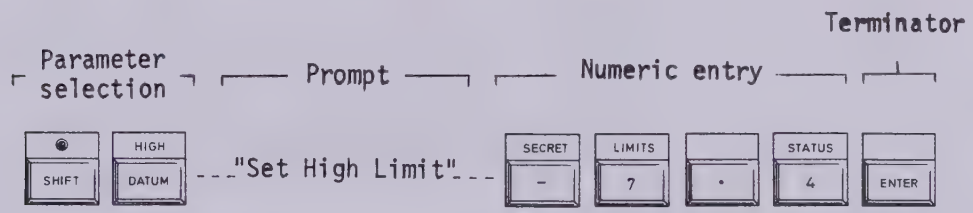
Introduction

9. All operations are carried out via the front panel keyswitches (or GPIB if option 6500-001 is fitted) which are used to enter commands and numerical values. Many keys have two functions, the secondary function being indicated on the top half of the push-button.



The secondary function is obtained by pressing the SHIFT key (the l.e.d. lights to indicate this) followed by the required second function key. Pressing any further key including SHIFT extinguishes the l.e.d. and cancels the secondary function mode.

10. Any command which requires numeric data to follow it, produces a prompt or selection menu on the display. When the prompt is displayed the numerical data should be typed in followed by ENTER:- e.g. to set a HIGH limits of - 7.4 dB(m).



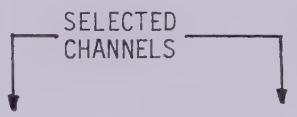
11. As ENTER is pressed, a terminator (dB(m) in this case) is echoed to the screen to confirm that the entry has been accepted. This will remain as long as the key is held down. If a mistake is made at any point the command can be entered again simply by starting the sequence again. If an ERROR message results, this indicates that an illegal input was attempted, e.g. attempting to set RANGE in excess of 10.9 dB(m) division:-

This will produce the message ** Error 12 ** meaning 'Entry overflow'. Other error codes used in 6500 are given in Table 1.

TABLE 1 ERROR CODES

GENERAL OPERATING ERRORS	
01	Attempt to enter more than eight markers.
02	Sweep data was invalid when last operation attempted.
03	Attempt to recall instrument settings from null memory. (i.e. No stored settings).
04	Relative measurements on R channel (SUB M and -R not allowed).
05	ΔF sweep width greater than F1-F2 range.
KEYBOARD ENTRY ERRORS	
11	Negative entry not allowed for attempted operation.
12	Entry overflow.
MEMORY OPERATION ERRORS	
21	Memory start/stop frequencies different to current screen settings.
22	Attempt to subtract null memory.
23	Attempt to use STORE AV on null memory.
24	Attempted memory operation on incorrect channel. (See table of valid operations).
GPIB ERRORS	
31	Attempt to position the brightline outside valid area with GPIB BL, BR or BP commands.
HARDWARE ERRORS	
41	Keyboard fault.
42	ZERO fail. Caused by defective probes or r.f. present.
43	Timeout on D/A read. (No valid range).
44	Timeout on SYNC. input. (Check sweeper).
45	Maximum RF input level exceeded.
46	Detector temperature range exceeded.

12. (1) Where an entry is made which can be independently set on the three channels, the entry will only affect the channels which are currently selected as indicated by the brightline display.

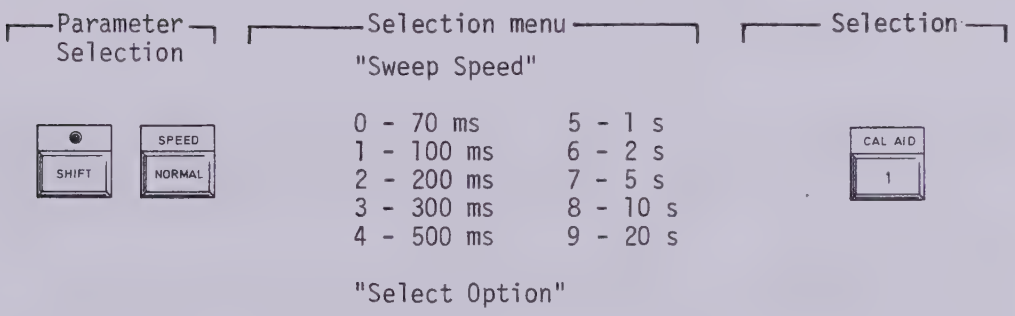


e.g. A = - 12.34 dBm B = - 56.78 dBm

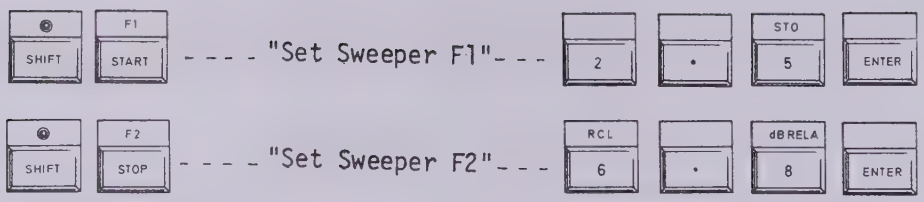
Both A and B channels (but not R) will be affected by the entry.

(2) When a selection menu is displayed, for example in setting the sweep SPEED or PLOT modes, the appropriate numeric key should be pressed, no ENTER key is required.

e.g. Set sweep SPEED of 100 ms:-



(3) When the instrument is first switched on, F1 and START will automatically be set to 0.01 GHz, and F2 and STOP to 18 GHz. Before any measurements are made, the F1 and F2 parameters of the sweeper being used should be entered, otherwise an incorrect frequency display will result. A frequency counter may be used to facilitate more accurate settings see Fig.2. The procedure is, select SHIFT, F1 and read the frequency counter e.g. 2.5 GHz; enter this value and terminate using the ENTER key. Select SHIFT, F2 and again check the frequency counter e.g. 6.8 GHz; enter this value and once again terminate using the ENTER key.



Note ....

If at any time the relationship F1 $\leqslant$ F2 $\leqslant$ 126 GHz is not maintained, the entry will be rejected and ** Error 12** message is displayed. When this happens set F2 first, then F1.

This sequence will also set START and STOP to F1 and F2 so a full width sweep of F1 to F2 will result.

KEYSWITCH FUNCTIONS

MODE Keys

13. The purpose of the MODE keys is to select the required channels and the way in which they will be used for measurement. In addition the MODE keys give control over the three memories. The mode should be set up by first selecting one of the four options:-

--- Select Channel 'A' for display.

-- Select Channels A & B for display

--- Select Channel 'B' for display

--Select Channel R for display

The above keys are independent and will initially provide a swept display of power on the selected channel(s). At switch on, the display is set automatically to channel A in dBm. If the dBm units are not required this can be changed via the UNITS key which allows the user to select a display in either dBm or mW. The mW scale is fixed at 0 - 50mW and cannot be altered in either RANGE or DATUM.

--- Switch between dBm (default) and mW scaling, if measurement is of absolute power.

To indicate that this mode is selected, the title "Power" will appear at the top of the screen, and the units will be displayed above the scaling information. The channels that have been selected will always be indicated below this title for the BRIGHTLINE information.

e.g. "A = +16.7 B = -49.32dBm" See Chap.1,Fig.1.

14. In many measurement systems a Live reference is required to remove variations in the sweeper's output both in frequency and time. This mode can be achieved via the -R key.

---Subtracts response on channel R from selected measurement channels before display to screen.

When this mode is selected it will be indicated by the title

"Gain/Loss (-Ref)"

whenever the live Reference mode is selected it will be indicated in the title by "(-Ref)".

Note.....

No relative or gain/loss measurement may be made on Channel R itself. Any attempt to do so results in an * * Error 04 * * message.

The effect this has is to remove the response on channel R (the reference channel) from the measurement channel(s) (A and/or B). This mode should be used for measurement when the output from the sweeper is liable to change in time, or when loading effects change the sweeper performance during the measurement.

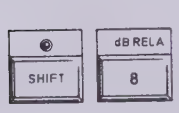
Note.....

Before any measurements are displayed in this mode, a sweep must be made on the R channel; this is not displayed and will be noticed as a delay before a trace appears.

The scaling will represent the difference in absolute power levels at the probes, and will be displayed in dB. If the measurement system is such that this represents a v.s.w.r. the scaling can be changed to cover a v.s.w.r. of 1.0:1 to 3.0:1. This is a fixed range and cannot be altered by RANGE or DATUM.

--- Switch between dB (default) and v.s.w.r.scaling if measurement is relative.

15. An additional facility is provided by the dB RELA and dB RELB keys. The two keys, (one for each channel A and B) allow you to select any point on the screen using the BRIGHTLINE to be rescaled at 0 dB. The two independent keys allow different positions to be set to 0 dB on the two measurement channels.



or

----- Measurement on channel A or B at BRIGHTLINE position is set to 0dB. RANGE is not adjusted.

When a 0dB relative point has been set, the title will become

"dB Relative"

If, in addition, the live Reference mode has been selected, this will again be indicated:

"dB Relative (-Ref)"

Note ...

Using this facility it is possible to perform a dB Relative function on only one trace when two channels are simultaneously displayed. This allows absolute power (dBm) and Relative measurements (dB) to be displayed at the same time; the title will, however, remain as above.

In performing the dB relative function, the numerical value subtracted from all displayed measurements can be found using the STATUS key, for details see paragraph STATUS key.

16. Memory operation. The STORE key and the SUB MEM key in the mode block refer to the three available memories (A, B or R), which are capable of storing a complete sweep of 422 measurement points.

Each of the operating modes previously described may be modified by use of these memories. For instance, the frequency response of a device may be removed from future measurements by storing the response and then subtracting the stored values before display (normalization).

In all cases, whenever a memory is being subtracted from a measurement, it is indicated on the title by the memory name (A, B or R) in brackets.

e.g. Gain/Loss (- A,R) indicates 'A' and 'R' memories are subtracted.

dB Relative (-Ref) (-B) indicates dB relative mode with live reference and the contents of memory 'B' being subtracted before display.

17. The STORE key allows the current trace(s) to be stored to memory. When pressed, the prompt --- Store to Memory --- appears and the current sweep in progress will stop. This should be followed by a key as indicated below.

- - - Stores current trace to Memory A.

This cannot be used when A & B are simultaneously displayed.

- - - Stores current trace to Memory B.

This cannot be used when A & B are simultaneously displayed.

- - - Stores current trace to Memory R.

This cannot be used when A & B are simultaneously displayed.

- - - Stores current Channel A trace to Memory A, and Channel B trace to Memory B. Only use when A and B are simultaneously displayed.

- - - Pressing 'NORMAL' cancels STORE mode, and sweep continues without any change to operating mode or memory.

In addition the facility is provided to average the contents of a memory with a current trace, and store the result. This is achieved by preceding the above keystroke sequences by SHIFT. This accesses the store average facility, and the prompt.

--- "AVERAGE TRACE TO MEMORY" ---

will appear. The operation remains the same as STORE but with the difference that the current trace is averaged with selected memory before it is stored to it.

e.g.

--- average current trace with memory A and store result to memory A.

Note ...

** Error 23 ** message is produced if an attempt is made to STORE AV to a memory which has no contents. The function is, however, performed assuming contents to be zero. No STORE is allowed in v.s.w.r. or mW units.

18. The operation of the SUB MEM key is as follows:-

Parameter
┌Selection┐ ┌─Prompt─┐ ┌Terminator┐

--- "Subtract Memory" ---

Subtract memory A from trace A. Use whenever Channel A is displayed.

Subtract memory B from trace B. Use whenever Channel B is displayed.

Subtract memory R from trace A and/or B as selected. Use whenever Channel A and/or B is selected.

Notes ...

(i) No memory can be subtracted from Channel R.

(ii) Memory R can be subtracted from both Channels A and B if selected.

(iii) It is not possible to subtract Memory A from trace B or vice-versa.

(iv) Message ** Error 22 ** will be generated if an attempt is made to subtract a memory with no contents.

19. Valid memory operations are summarized in Table 2. Any attempt to select the memories in a way other than those listed will result in ** Error 24 ** message being displayed. The contents of any memory may be examined at any time by pressing SHIFT followed by the channel memory required.

e.g.

---Displays Memory A.

TABLE 2 VALID MEMORY OPERATIONS

CHANNEL	A	B	A & B	R
Store trace to memory	A B R	A B R	A & B	A B R
Subtract Memory	A R	B R	A B R	

SWEEP Keys

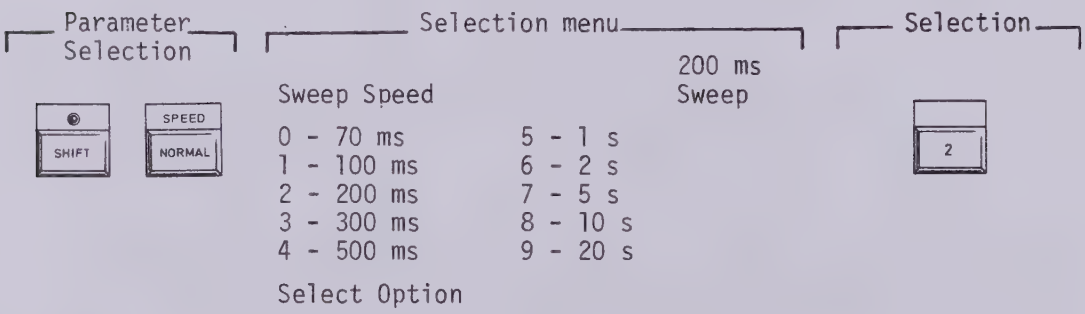
20. Two methods of sweeping are available: NORMAL and AVERAGE. When NORMAL key is selected, measurements are made at each of the 422 positions across the screen, displayed and directly stored to the appropriate display memory. The AVERAGE key enables signal processing to provide noise reduction by averaging the measurement taken with the contents of the display memory corresponding to the same ramp position. This is done for every measurement point and has the effect of reducing noise over consecutive sweeps. This process restarts whenever the AVERAGE key is pressed.

Selects averaging mode and restart averaging process

Note ...

The averaging mode should be started when a steady trace is present. If changes in power level occur during a sweep in this mode, the trace will not return to a true representation of the measurement until many sweeps have occurred as it treats the change as noise to be removed. If a change to the system is made, AVERAGE should be pressed again to restart the process. To cancel AVERAGE press NORMAL.

21. The actual number of measurements taken at each measurement point and consequently the sweep SPEED is selected by the secondary function as shown below.



Notes ...

(i) Pressing the numeral 2 selects a sweep SPEED of 200 ms and terminates the entry at the same time. No ENTER key operation is necessary.

(ii) The speeds shown are nominal and will vary depending on power level, shape of trace and any delays introduced by sweep hesitation etc.

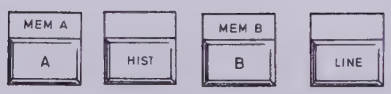
(iii) The sweep speed and sweep mode selected are displayed on the screen in the top right corner.

(iv) Sweep speed 0 provides reduced resolution - only half the number of measurement points are taken with one measurement occupying two display points - but retains a "real time" feel for adjustment or peaking of devices under test.

22. The FREEZE mode allows the sweep to be stopped for examination or photography. In this mode the ramp output will track any movement of the brightline allowing frequency accuracy checks to be made. This key has a toggle action, and pressing it again will cause the sweep to restart.

DISPLAY keys

23. There are two methods of presenting the trace on the screen, HISTogram or LINE format. This is for visual effect only and does not affect any operation of the instrument. It is useful when displaying two traces simultaneously to have them in different forms for easy identification of channels. When pressing the HIST or LINE keys, the selected channels are affected.



---- Sets up display of channel A in Histogram and B in line format.

Note: Channel R is displayed on the same format as selected for Channel A.

PLOT key

24. The 6500 has a facility enabling a hard copy of the display to be obtained using a standard X-Y (analogue) plotter. Three outputs are provided from the rear panel for connection to the X, Y and Pen-Lift inputs of the plotter. The X and Y outputs provide signals in the range 0 - 10 volts, while the Pen lift output is an open-collector drive.

At any time when there is a complete trace available on the screen, press PLOT.

---- A selection guide is displayed covering all the facilities available in the PLOT Mode:

1 - Set Pen Bottom Left
2 - Set Pen Top Right
3 - Set Pen to Origin
4 - Draw Axes
5 - Label Axes
6 - Plot
7 - Set Pen Lift
8 - Set Plot Speed

1) The X and Y outputs are set to minimum, allowing adjustment of the plotter sensitivity and zero controls to give a position at the bottom left of the paper.

2) The X and Y outputs are set to maximum, allowing adjustment of the plotter sensitivity and zero controls to give a position at the top right of the paper.

3) When a plot is made space is allowed for labelling of the axes. If this is not required, this option allows the origin of the displayed trace to be set as opposed to bottom left ((1) above).

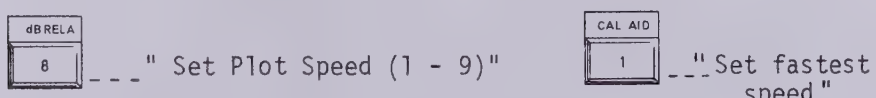
4) The X and Y axes are plotted including 'tick' marks indicating positions of the frequency graticule lines. Ticks are also provided to show the positions of any markers present, including the brightline.

5) The DATUM(s) and RANGE(s) are written to the left of the Y-axis, the DATUM(s) at the top. If two traces are being plotted, a pause is introduced when the data pertaining to the A trace has been written, allowing a pen change. When ready, press '1' as prompted to continue the labelling.

6) The displayed traces are copied to the plotter. If both A and B channels are selected, B is plotted first. After a pen change, if necessary, press the numeral 1 key as prompted to continue the plotting.

7) Set sense of pen lift drive. Normally pen lift output is high impedance for PEN UP. Select INVERT for low impedance for PEN UP. Options are presented as a separate prompt:

8) When plotting and drawing alphanumerics the 6500 maintains the pen speed constant. Select pen speed from 1 to 9 (1 is fastest) to suit plotter slew rate. Prompt is displayed -



As each function is completed, the instrument returns to the initial selection guide to allow further instructions. To return to normal operation press NORMAL.

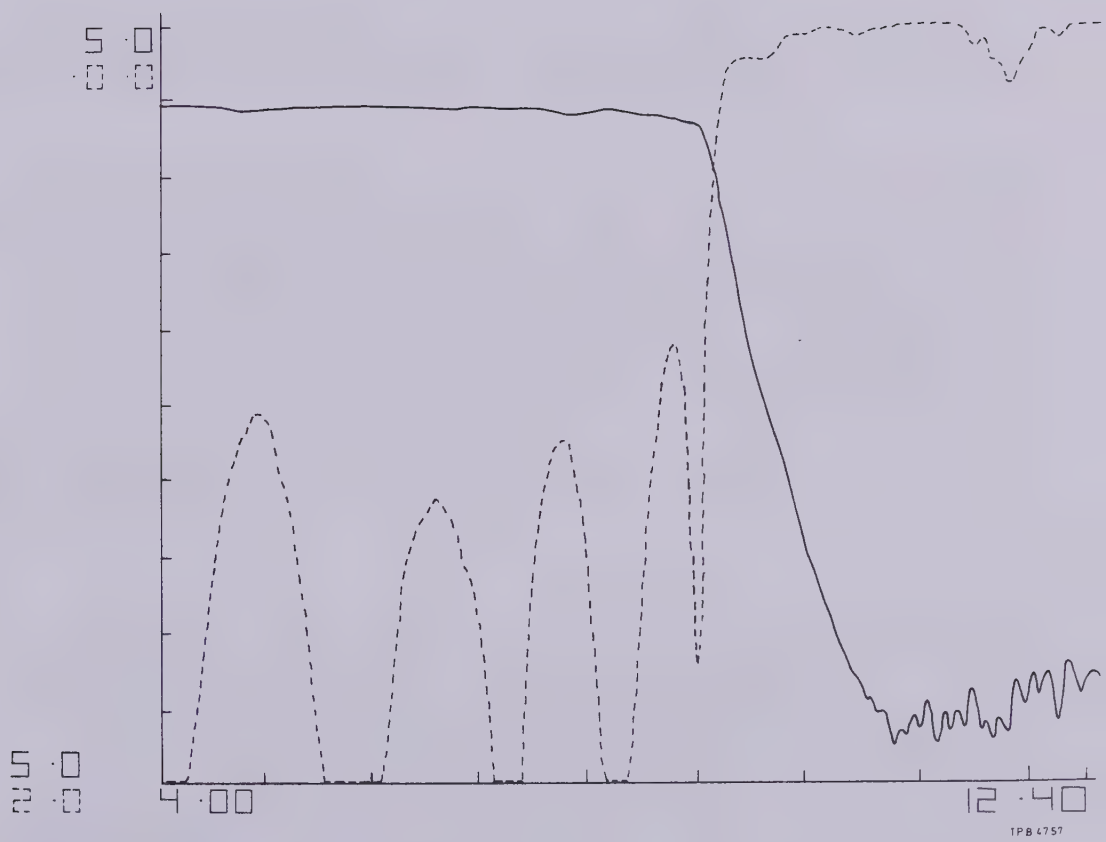


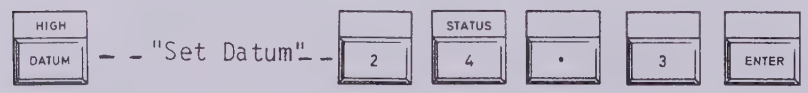
Fig.5 Typical X-Y plotter presentation

SET Keys

25. The four SET keys and their associated secondary functions allow operating parameters to be entered on the numerical keyboard. Two keys refer to frequency related parameters and two refer to amplitude levels or ranges.

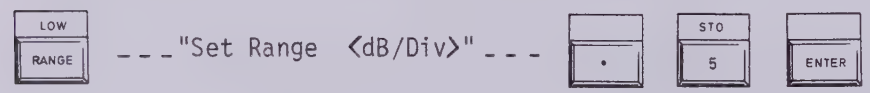
When the instrument is first switched on, the display shows an amplitude scale of + 20 to - 80 dBm (DATUM + 20 dBm, RANGE 10 dBm/division) on channel A embracing the total dynamic range of the instrument. These two parameters can be entered individually for each channel A, B and R, and only the channels currently selected will be altered when the parameter is entered.

Set DATUM within range + 99.9 to - 99.9 dB(m), e.g.



As each Numeric key is pressed, the number is displayed to the screen until ENTER is pressed, whereupon their terminator 'dB(m)' will be displayed, showing the entry has been accepted. The entry may be abbreviated if no decimal data is required.

26. Set RANGE within range 0.1 to 10.9 dB(m)/division e.g.



As each parameter is entered, the scaling will be re-written and the sweep will be automatically restarted.

Pressing the AUTO key will automatically select values of RANGE and DATUM to give optimum display of the screen contents.

Note.....Pressing RANGE or DATUM keys will have no effect when displaying v.s.w.r. or mW scaling.

27. Different HIGH and LOW limits may be entered for the A and B channels. If the LIMITS facility has been enabled (as indicated by an 'L' on the top left corner of the screen) each complete sweep will be checked to ensure it is within the present limits for that particular channel. If any points in the trace exceeds these limits, a message is displayed at the top of the screen indicating which limits have been exceeded. If, on a following sweep the sweep returns within the limits, the message is erased and replaced with the original title.

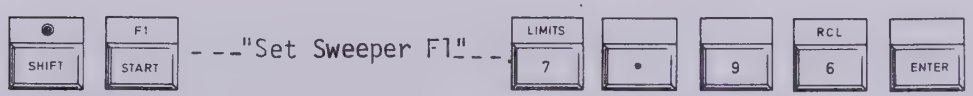
To Set limits select the channel that the limits will apply to, and enter as for DATUM or RANGE (above) but precede the sequence by SHIFT.

e.g. Set HIGH limit within $\pm$99.99 dB(m)

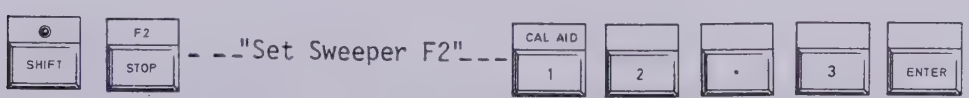
These limits will be stored until new values are entered, even if the LIMITS facility is disabled.

28. The frequency information presented on the bottom line of the display is calculated assuming a linear response from the sweeper being used as driven by the external ramp. To do this, the frequencies generated by the sweeper at the top and bottom of the range of the applied ramp must be entered into the 6500. These frequencies are termed 'F1' and 'F2' respectively. Providing the sweeper is stable, it should only be necessary to enter these values once.

e.g. Set up X-band sweeper.



When the prompt Set Sweep F1 is displayed the ramp is set to the bottom of the range. Confirmation of the low limit F1 frequency is best obtained by reference to a frequency counter connected as shown in Fig. 2.



Here the ramp is set to the top of the frequency range and this frequency is again best confirmed by the frequency counter as described in the setting of F1.

Note ....

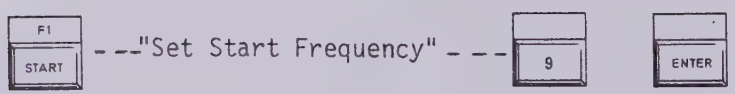
(1) Some sweepers have front panel controls which affect F1 and F2 even when driven by an external ramp. If these are adjusted after the 6500 has been set up the frequency information may be incorrect.

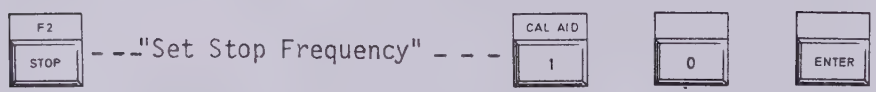
(2) When using the variable 0-20V ramp a d.v.m. may be necessary to check for correct ramp output voltage limits using coarse and fine screwdriver adjustment.

(3) If an attempt is made to set F2 <F1, ** Error 12 ** message is displayed.

29. Once the 'F1' and 'F2' parameters have been set, it is possible to select any portion of this range to correspond to a full sweep on the 6500. As there are 422 measurement points and 4096 possible ramp points it is possible to expand the frequency scale approximately ten times without any significant loss in resolution. To select the required frequency band, use 'START' and 'STOP'.

e.g. Set a band of 9 - 10 GHz (F1 and F2 previously set at 7.96 and 12.3 GHz).





As each parameter is entered, the alphanumeric scaling and frequency related graticule lines are adjusted.

Note.....

(1) An entry will be rejected as an error if the condition

F2≫ STOP≫ START≫ F1 is not met.

(2) Frequency graticule lines will not be generated for sweep widths less than 100 MHz.

30. The BRIGHTLINE may also be used for setting START and STOP making numeric entry unnecessary.

e.g. Press START key and move the BRIGHTLINE to the required start point.

Note.....

As enter is pressed, the brightline frequency is copied to the screen and the terminator 'GHz' displayed showing the entry has been accepted. The BRIGHTLINE is also moved to maintain its frequency position, to the far left for START and to the right for STOP.

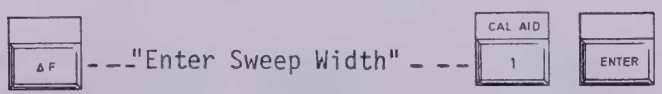
In addition the ΔF Key may be used to set symmetrical sweeps, this is discussed under the BRIGHTLINE Keys section.

BRIGHTLINE AND RELATED KEYS

31. The BRIGHTLINE appears on the display as a single vertical line. It can be moved anywhere within the graticule window using the rotary control at the bottom right of the instrument. The BRIGHTLINE is used to provide single spot measurements displaying both the frequency and amplitude of the measurement(s), where it intersects the trace(s). The spot measurements are derived from the internal data store, and are therefore unaffected by front panel settings. Full accuracy is always maintained. Movement of the BRIGHTLINE is inhibited during the first sweep after the measurement has been restarted, this is to ensure that the BRIGHTLINE will not display invalid data from previous sweeps, this is only noticeable on very slow sweep speeds.

The position of the BRIGHTLINE is also used for setting START and STOP as shown, and also for entering symmetrical sweep widths using the ΔF Key:

e.g. Set total sweep of 1 GHz about BRIGHTLINE position.



At the prompt Enter Sweep Width, move the BRIGHTLINE to the point about which a symmetrical sweep is to be made. On pressing the ENTER key a 1 GHz sweep about the position of the BRIGHTLINE is obtained.

The scaling of the frequency graticule lines and the START and STOP parameters displayed on the screen will be adjusted, and a new sweep will be started.

Note .....

The BRIGHTLINE can be moved to the required centre frequency at any time until ENTER is pressed. If a sweep width is entered which would generate an illegal START and/or STOP frequency the 6500 will attempt to provide the correct width, but will not necessarily be symmetrical about the BRIGHTLINE position.

MIN/MAX Keys

32. The MAX or MIN keys are used to identify Maximum and Minimum data points in the currently displayed sweep(s). When one of these keys is pressed, the sweep update is stopped and the BRIGHTLINE moved to the Maximum or Minimum position depending on the Key pressed. This works on the actual numerical data and not the position of the data on the screen. The BRIGHTLINE spot measurement data is also updated.

e.g. Find Maximum and Minimum point.

--- BRIGHTLINE is automatically moved to Maximum data point on current trace and amplitude and frequency information is updated.

--- BRIGHTLINE is automatically moved to Minimum data point on current trace and amplitude and frequency information is updated.

MARKER key

33. MARKERS identical to the BRIGHTLINE may be positioned anywhere within the graticule window to identify important frequency points with the MARKER Key. When this Key is pressed a Marker will be left at the brightline position. Up to eight markers may be displayed on the screen at any time. Any individual Marker may be removed by placing the brightline back over it and pressing MARKER again, alternatively all may be removed by using the Secondary function, ERASE.

--- Place MARKER at BRIGHTLINE Position, or Remove MARKER if BRIGHTLINE is coincident with one.

--- Remove all MARKERS

LOCAL key

34. The integral l.e.d. indicator in the LOCAL key monitors the state of the instrument under Remote control. The l.e.d. off indicates Remote control and the front panel keys (and Brightline control) are inoperative apart from the LOCAL Key. Providing the LOCAL LOCKOUT message has not been sent to the instrument, Manual control can be regained by pressing LOCAL. This Key has no effect when the instrument is already under manual control.

MISCELLANEOUS SECONDARY FUNCTIONS

ZERO Key

35.

The ZERO facility is used to set up the instruments signal channel after Power on and when changes in ambient temperature, or changes in the system occur.

36. The ZERO facility must only be used with NO INCIDENT RF at the Detector. If a ZERO is attempted with r.f. power applied to the detectors an error will be indicated if it cannot be completely nulled out and all subsequent measurements will be affected.

37. When a channel has been successfully ZEROED, the message 'Ready' will be displayed next to the channel identification. If no Probe is connected or the channel fails to ZERO, the messages 'No Probe' or 'Fail' will be displayed.

e.g. RF power on channel R, No probe in B.

Autozero:

A Ready
B No Probe
R Fail

38. If a situation other than all channels being 'Ready' occurs the message describing the ZERO operation will be left displayed. No error is produced for a 'No Probe' condition, but ** Error 42 ** message will be produced for a 'Fail'. A channel which has been successfully ZEROED will display a Power level, when averaged, between -55 and -61 dBm.

Note ....

The ZERO operation also sets up internal calibration which affects 10 dB range overlaps. Consequently if the ZERO operation occurs with r.f. power present these ranges covering all power levels will also be affected. However, if the ZERO drifts due to temperature changes or system effects, the inaccuracy introduced is greatest at low power levels. Before measurements are made at low power levels, a ZERO operation should be repeated with the r.f. turned off.

STO and RCL keys

39. Up to nine complete instrument states may be saved for recall later. To save an instrument setting press the SHIFT and STO keys.

The prompt, Store Settings is then terminated by operating Store No. required (1-9). The following parameters are stored.

Limits and limit checking status.

DATUM and RANGE(s)

F1, F2, START and STOP

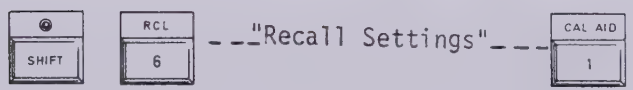
Sweep Speed

Channels and Mode including dB Rel values

Markers

Temperature correction ON/OFF

To recall one of these stores use RCL



The parameters in Store 1 are re-entered into the instrument and the STATUS is displayed for confirmation of the current state of the instrument. If nothing has been entered to the store ** Error 03 ** message will be indicated if an attempt is made to recall data from it. To assist in recording channel memory contents, a sample Worksheet is illustrated to identify the contents of each STORE.

Note .....

The contents of channel memories are NOT stored, use STORE.

6500 AMPLITUDE ANALYSER - INSTRUMENT SETTINGS WORKSHEET

PARAMETER	STORE 1	STORE 2	STORE 3	STORE 4	STORE 5	STORE 6	STORE 7	STORE 8	STORE 9
F1 FREQUENCY									
F2 FREQUENCY									
START FREQUENCY									
STOP FREQUENCY									
SWEEP SPEED									
CHANNEL									
DATUM (A)									
RANGE (A)									
DATUM (B)									
RANGE (B)									
DATUM (R)									
RANGE (R)									
-R									
SUB M (A/B/R)									
dB REL (A/B)									
dB REL REF (A)									
dB REL REF (B)									
UNITS									
AVERAGE ON/OFF									
LIMITS ON/OFF									
HIGH LIMIT (A)									
LOW LIMIT (A)									
HIGH LIMIT (B)									
LOW LIMIT (B)									
MARKER 1									
MARKER 2									
MARKER 3									
MARKER 4									
MARKER 5									
MARKER 6									
MARKER 7									
MARKER 8									
TEMP.CORRn.ON/OFF									

Fig. 6 Sample work sheet

STATUS key

40. The current status of the instrument is displayed on the screen using the SHIFT and STATUS keys. Information is then provided about the parameters of the instrument which are not immediatley visible from the display, and these are also automatically displayed when RCL is selected.

- - - Displays Instrument Status as illustrated.

6500 Status

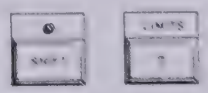
Channel A (High) + 99.00
Channel A (Low) - 99.00
Channel B (High) + 99.00
Channel B (Low) - 99.00
Limits Disabled

Temperature Correction ON

Sweeper F1 = 7.94
Sweeper F2 = 12.51
dB Rel A = 0.00
dB Rel B = 0.00
GPIB Address = A(8)

LIMITS Key

41. LIMITS is a toggle action key and is used in conjunction with the SHIFT key to both enable and disable the limits checking facility. Checking the operating limits takes approximately 10 ms. Consequently, disabling the facility will provide slightly faster sweep speeds. An "L" is displayed above the amplitude scale(s) on the upper left screen when the facility is enabled.



- - - Enable/Disable limit checking facility. Limit values not affected.

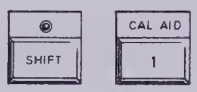
SECRET key

42. To remove the frequency scaling information, press SHIFT and SECRET keys. This is for use when frequency bands being used should not be generally displayed or are irrelevant. Usually used for photography/ plotting. This function has a toggle action.

--- Remove/Restore frequency related information.

CALAID key

43.



--- SHIFT and CALAID keys are used when initially setting up the instrument signal channel and for later re-calibration. It can also be used as a confidence check by the user.

The display removes the graticule and instead shows a measurement of power on the selected channel, and identifies which range(s) the instrument is using for the measurement as shown below.

```
CALIBRATION AID

KEYS:0   CYCLE, 1-6  HOLD RANGE
     7-9 SELECT CHANNEL A,B,R

   TEMPERATURE SENSOR:    - 2.87

   RANGE          R0 R1 R2    POWER

1 - 1 - +16       1  0  0    +12.53
2 -15 - - 1       1  0  1
3 -25 - -15       0  0  0
4 -35 - -25       0  0  1
5 -45 - -35       0  1  0
6 -55 - -45       0  1  1

CHANNEL = A
```

Fig. 7 Calibration aid display

44. When in CALAID the Keys 0-9, SHIFT and SECRET have different functions:

Ø	An attempt is made to make a measurement on each of 6 ranges and readings which the instrument considers valid are displayed. This continues cyclically.
1 - 6	Select Range 1 - 6 and HOLD (indicated by flashing "H" adjacent to selected range). Only when valid measurements are made on this range will they be displayed.
7,8,9	Select which channel measurement is to be made on; A, B or R.
SHIFT SECRET	Select Temperature Correction ON/OFF (toggle action). If selected, the readings from the Temperature sensor are displayed, otherwise OFF will be displayed.

45. To check the integrity of the signal channel, adjust the r.f. power to a level where a reading is obtained on two adjacent ranges. The readings should be the same. The bar on the right will indicate any difference between the two.

Note ....

(1) A valid ZERO operation must have been performed.

(2) The bar should settle to the same level as the horizontal line on the centre; to reset the bar, reselect the channel.

(3) The setting of LINE and HISTOGRAM for the A or B channels may be disturbed after using CALAID.

46. The temperature correction facility makes allowances for variations in detector characteristics at different temperatures. A reading from the sensor is displayed for each Channel in CALAID if for any reason this is not required it can be switched out. The correction applied is insignificant in the temperature range 19-27 ^{o}C.

GENERAL PURPOSE INTERFACE BUS (GPIB) FUNCTIONS

47. The GPIB interface, offered as an optional accessory allows the instrument to be coupled to a controller.

The essential purpose of the GPIB functions and mnemonics are described below. Further information on the general features and applications of the GPIB system can be obtained from the separate GPIB manual offered as an optional accessory.

48. SH1: Source handshake (complete capability)

The source handshake sequences the transmission of each data byte from the instrument over the bus data lines. The sequence is initiated when the function becomes active, and the purpose of the function is to synchronize the rate at which bytes become available to the rate at which accepting devices on the bus can receive the data.

49. AH1: Acceptor handshake (complete capability)

The acceptor handshake sequences the reading of the data byte from the bus data lines.

50. T6: Talker function (no talk only function)

The talker function provides the 6500 with the ability to send device dependent messages over the bus to other devices. The ability of any device to talk exists only when it has been addressed as a talker.

51. L4: Listener function (no listen only function)

The listener function provides a device with the ability to receive device dependent messages over the bus. The capability exists only when the device is addressed to listen via the bus by the controller.

52. SR1: Service request function (complete capability)

The service request function gives the 6500 the capability to inform the controller when it requires attention.

53. RL1: Remote/local function (complete capability)

The remote/local function allows the 6500 to be controlled either by the local front panel keys or by device dependent messages over the bus.

54. DC1: Device clear function (complete capability)

Device clear is a general reset and may be given to all devices in the system (DCL) or only to addressed devices (SDC). On receipt of DCL or SDC the 6500 performs a software reset, returning the instrument to its power-on state. The software reset includes the following actions:

Self test.
Clear all memories.
Set detector zero and null voltages to nominal values.
Initialise all instrument settings.
Read GPIB address switch.
Return 6500 to LOCAL control.

Note: A self test failure may cause a GPIB interface error condition or suspend GPIB activity. The 6500 must be switched off to clear this condition.

55. E1: Open collector drives

The GPIB drivers fitted to the 6500 have open-collector, rather than tristate, outputs.

GPIB OPERATION

Setting the GPIB address

56. The instrument's talk/listen address is selected by the address switch as shown in Fig.8. The address switch is positioned on the GPIB interface unit alongside the GPIB connector on the rear panel. The instrument's internal address register will be updated by reading the setting of the address switch. This operation is performed at power-on and on receipt of a device clear message. The current GPIB address is shown at the bottom of the status display when the interface is correctly installed.

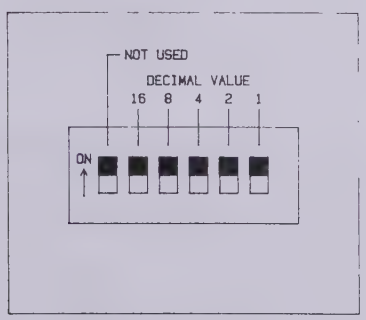


Fig.8 GPIB Address Switch

Note: The valid GPIB address range is 0-31. The 6500 address is preset to 8 at the factory. Before changing this check controller manuals for reserved addresses.

Remote operation

57. On receipt of the Remote Enable (REN) message from the GPIB the 6500 switches to remote operation, indicated by the LOCAL l.e.d. being extinguished. No instrument settings are changed but all front panel keys except LOCAL are disable and their functions come under GPIB control.

58. Unless inhibited by the Local Lockout (LLO) message the instrument can be returned to local control by pressing the LOCAL key or sending a Go to Local (GTL), Interface Clear (IFC) or Not Remote Enable (REN) GPIB message.

GPIB Program Codes

59. All valid GPIB program codes are listed in Table 3. These include equivalents for all front panel keys (except LOCAL) with additional codes for special functions. Note that access to the secondary key functions is achieved by using the primary function code preceded by 'SH', 'SH' is treated by the instrument as a program code corresponding to the SHIFT key.

60. Program codes may be combined in a string without individual terminators, although spaces or commas may be included to improve clarity. These will be ignored by the instrument.

Data Entry and Terminators

61. Some program codes require numeric data terminated with 'E'. This is treated by the 6500 as a program code for the ENTER key. Complete compatability with manual operation is thus maintained.

For example the program code sequence 'SD-10E' is equivalent to pressing:

Program codes requiring use of the 'E' terminator are:

SD SR SS SP DF	Set DATUM, RANGE, START FREQ.,STOP FREQ., Δ F SWEEP WIDTH.
SHSD SHSR SHSS SHSP	Set HIGH LIMIT, LOW LIMIT, SWEEPER F1, SWEEPER F2
BP WD	Set brightline position, Write data to 6500.

Some program codes use a single character qualifier and do not require the 'E' terminator. These are as follows:

SH4 (1-9)	Store settings in memories 1-9.
SH5 (1-9)	Recall settings from memories 1-9.
SHN (0-9)	Select sweep speed 0-9.

Positioning the Brightline

62. Program codes 'MX' and 'MN' operate in the same way as the MAX and MIN keys. Three other non key-related codes 'BP', 'BL' and 'BR' give more direct control over the brightline position.

63. The screen is divided into 422 brightline measurement positions and 211 physical brightline positions. Brightline control is implemented in terms of measurement position at all times. The 'BL' and 'BR' commands move the brightline one measurement position left and right respectively. Thus multiple 'BL' or 'BR' commands will only move the brightline physically on alternate executions, but each command will move the brightline to a new measurement position. The 'BP' command is used to move the brightline to a specific measurement position and should be followed by an integer in the range 0-421 terminated with 'E'.

e.g. BP123E will send the brightline to measurement position 123.

TABLE 3 - GPIB PROGRAM CODES

KEY	CODE	FORMAT	FUNCTION
A	CA	CA	Select absolute power measurement on A
B	CB	CB	Select absolute power measurement on B
R	CR	CR	Select absolute power measurement on R
A&B	CC	CC	Select absolute power measurement on A&B
-R	SLR	SLR	Subtract live reference (R channel)
STORE A	STA	STA	Store trace to memory A
STORE B	STB	STB	Store trace to memory B
STORE R	STR	STR	Store trace to memory R
STORE A&B	STC	STC	Store traces to memories A&B
SUB M A	SBA	SBA	Subtract memory A
SUB M B	SBB	SBB	Subtract memory B
SUB M R	SBR	SBR	Subtract memory R
UNITS	U	U	Change measurement units of current mode
DATUM	SD	SD-14.7E	Set display datum in dB(m)
RANGE	SR	SR10E	Set display range in dB/division
START	SS	SS7.95E	Set start frequency in GHz
STOP	SP	SP12.34E	Set stop frequency in GHz
AUTO	AR	AR	Auto range current display
F1-F2	FW	FW	Select full width sweep (F1-F2)
F	DF	DF3.5E	Set F sweep width (brightline = centre)
MAX	MX	MX	Set brightline to maximum trace point
MIN	MN	MN	Set brightline to minimum trace point
MARKER	MK	MK	Position or remove marker at brightline
NORMAL	N	N	Select normal sweep mode
AVERAGE	AV	AV	Select averaging sweep mode
FREEZE	FZ	FZ	Toggle freeze mode (see text)
HIST	H	H	Set histogram mode for current trace(s)
LINE	L	L	Set line mode for current trace(s)
PLOT	P	P	Enter plot mode (see text)
MEM A	SHCA	SHCA	Display contents of memory A
MEM B	SHCB	SHCB	Display contents of memory B
MEM R	SHCR	SHCR	Display contents of memory R
ST.AV A	SHSTA	SHSTA	Store mem/trace average to memory A
ST.AV B	SHSTB	SHSTB	Store mem/trace average to memory B
ST.AV R	SHSTR	SHSTR	Store mem/trace average to memory R
ST.AV A&B	SHSTC	SHSTC	Store mem/trace averages to memories A&B
HIGH	SHSD	SHSD-10.25E	Set high limit in dB(m)
LOW	SHSR	SHSR-45.75E	Set low limit in dB(m)
F1	SHSS	SHSS1.96E	Set sweeper minimum in GHz
F2	SHSP	SHSP18.04E	Set sweeper maximum in GHz
CALAID	SH1	SH1	Enter calibration mode (see text)
STATUS	SH4	SH4	Display current instrument status
STO	SH5	SH51	Store instrument settings in memory 1-9
RCL	SH6	SH61	Recall instrument settings from mem 1-9
LIMITS	SH7	SH7	Enable/disable limit checking facility
dB REL A	SH8	SH8	Select relative measurements on A
dB REL B	SH9	SH9	Select relative measurements on B
SECRET	SH-	SH-	Select frequency secret mode
ZERO	SHAR	SHAR	Perform detector auto zero
ERASE	SHMK	SHMK	Remove all markers from display
SPEED	SHN	SHN1	Select sweep speed 0-9

KEY	CODE	FORMAT	FUNCTION
N/A	SH2	SH2	Select synthesiser mode (see text)
N/A	SH3	SH3	Step frequency in synthesiser mode
N/A	RA	RA	Prepare channel A reading for talk mode
N/A	RB	RB	Prepare channel B reading for talk mode
N/A	RR	RR	Prepare channel R reading for talk mode
N/A	RF	RF	Prepare frequency reading for talk mode
N/A	RS	RS	Prepare status reading for talk mode
N/A	BP	BP123E	Set brightline position 0-421
N/A	BL	BL	Move brightline one position left
N/A	BR	BR	Move brightline one position right
N/A	WD	WD-12.35E	Write data at brightline (see text)
N/A	WT	WTtext	Write title to top line of screen
N/A	SQ	SQ00101	Set SRQ interrupt mask (see text)

64. The brightline is used as a cursor for reading amplitude and frequency data and also for positioning markers, writing data and setting dB REL reference points and Δ F centre positions.

65. Attempting to position the brightline outside its valid range (0-421) will cause the 6500 to indicate an **Error 31** message.

Reading Data from the 6500

66. When addressed to talk the 6500 can output data relating to various parameters. In order to obtain the data required the instrument must first be sent a program code indicating the parameter for which data should be output when next addressed to talk. These codes are as follows:

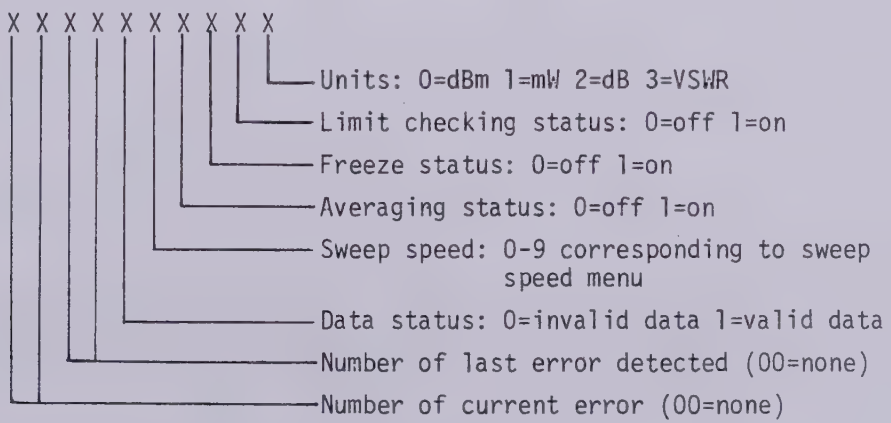
RA	Read amplitude of channel A at brightline position.
RB	Read amplitude of channel B at brightline position.
RR	Read amplitude of channel R at brightline position.
RF	Read frequency at brightline position.
RS	Read instrument status string.

One of these codes must be sent prior to each 6500 talk sequence.

67. Numeric data (amplitude and frequency) is output to 3 decimal places resolution in standard NR3 format as described in the GPIB manual. Data is terminated with EOI and CR LF and is in current measurement units (always Hz for frequency).

i.e. sn.nnnEsnn CR LF (s=sign +/-)

68. Status information is output as a 10 character string. Each element of the status string has a specific meaning as shown below.


X X X X X X X X X X
Units: 0=dBm 1=mW 2=dB 3=VSWR
Limit checking status: 0=off 1=on
Freeze status: 0=off 1=on
Averaging status: 0=off 1=on
Sweep speed: 0-9 corresponding to sweep speed menu
Data status: 0=invalid data 1=valid data
Number of last error detected (00=none)
Number of current error (00=none)

Using the Status String

69. The first four characters in the status string deal with error conditions. Whenever an error condition is encountered the 6500 displays an error number on the top line of the CRT. At the same time this two digit number is written into the first two pairs of characters in the status string. The first pair indicate that the error is current and is reset to 00 when the error message is removed from the display by a change in operating mode. The second pair remains until another error is encountered.

70. The fifth character in the status string indicates when valid measurement data is available for processing. Measurement data becomes invalid under the following conditions:

During the non-displayed reference sweep and the first displayed sweep following a change in measurement mode or an AUTO RANGE or NORMAL operation.

During the AUTO ZERO operation.

71. Some operations require measurement data to be valid before they can commence. These are as follows:

STA	STB	STR	STC	Store trace to memories A,B,R,A&B
SHSTA	SHSTB	SHSTR	SHSTC	Store average to memories A,B,R,A&B
FZ				Only requires valid data when toggling into FREEZE mode
P				Enter PLOT mode
MX	MN			Brightline to Max/Min point

Attempting any of the above operations with invalid measurement data will cause an **Error 02**. The status string should be checked for valid data before any of these operations is attempted.

72. The sixth character in the status string indicates the current sweep speed. The number (0-9) corresponds to the sweep speed menu numbers.

73. Characters 7,8 and 9 are flags indicating the current status of averaging, freeze and limits checking modes (0=off, 1=on). Freeze and limits checking codes have a toggle action. The status string may be checked to ascertain the status of the function before sending the program code.

74. The last character in the status string gives an indication of the current measurement units and may be used to quantify data sent by the 6500.

Writing titles and data to the 6500

75. The 'WT' program code allows the controller to place a title of up to 28 characters on the top line of the display. The title should normally be terminated with 'S', although termination will occur automatically on receipt of the 29th character or the controller's CR LF end of line sequence. All standard ASCII characters may be used in the title string.

e.g. 'WTFilter type 24$'

Sending an ASCII code with bit 7 set will cause that character to flash at an approximate 2Hz rate.

Note that a title will overwrite the measurement mode indicator (Power, Gain/Loss etc.). To remove the title and restore the display use the 'N' (NORMAL) program code.

76. The 'WD' program code allows amplitude data to be written to the 6500. The instrument treats this data in the same way as data read from its own internal measurement system and updates the display accordingly. The 6500 must be in FREEZE mode for the data to be retained. Data received is used to update the display at the current brightline position, by stepping the brightline a complete trace (422 points) may be written to the display for subsequent storage in one of the trace memories. The data written may be a trace previously read from the 6500. In this way data may be read from the 6500 and stored on magnetic tape or disc for use as a reference trace in future measurements. The 'WD' code should be followed by numeric data in units appropriate to the current measurement mode (dBm, mW, dB, VSWR) and terminated by 'E'.

e.g. 'WD-12.34E'

Each value received is displayed on the CRT to indicate successful data transmission.

Synthesizer Mode

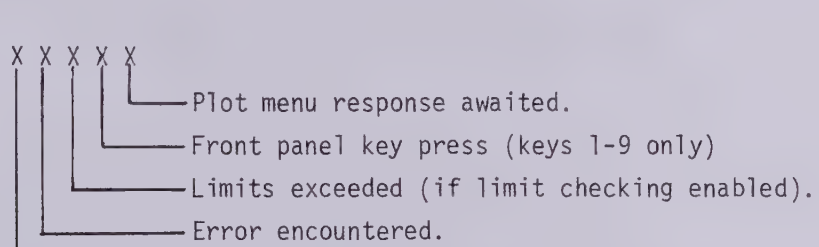
77. The Synthesizer mode is a GPIB function only and allows the 6500 to be used with a GPIB controlled frequency synthesizer (e.g. MI 6800 series). In this mode the ramp output voltage is not used. Synthesizer mode is invoked with the 'SH2' program code. The instrument operates in a manner similar to the normal sweep mode except that it pauses before taking each measurement and waits for the 'SH3' code to be sent by the controller. On receipt of 'SH3'the instrument takes a measurement and steps to the next measurement point. A new sweep is started after 422 measurements have been taken. The frequency of each measurement point must be calculated by the system controller and sent to the synthesizer. All program codes are available for use in synthesizer mode. Note that some codes ('SD', 'SR', 'AR') cause the sweep to be restarted. The controlling program should be aware of this fact in order to maintain correct frequency tracking between the 6500 and the synthesizer. To exit from synthesizer mode use the 'N' (NORMAL) code.

Calibration Aid

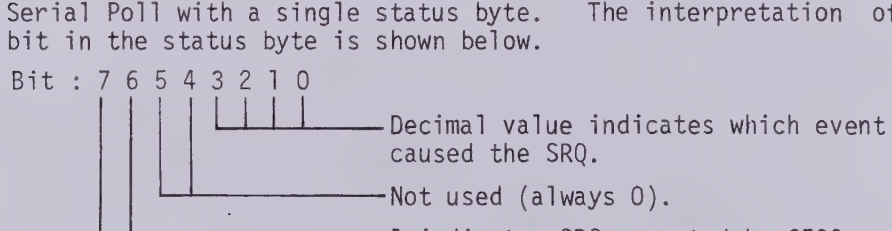
78. The 'SH1' program code which selects calibration mode is included for completeness. However, calibration is essentially a manual operation and the mode would not normally be invoked by a GPIB control program.

SRQ (Service Request) Functions

79. The 6500 can be programmed to assert the SRQ (Service Request) signal on the occurrence of various operating events. To enable or disable the required functions the instrument must be sent an SRQ mask using the 'SQ' program code. The 'SQ' code should be followed by a string of five ASCII digits. Each digit relates to a specific function as shown below and should be either '0' to disable the function,or '1' to enable the function.


X X X X X
Plot menu response awaited.
Front panel key press (keys 1-9 only)
Limits exceeded (if limit checking enabled).
Error encountered.
End of sweep.

80. If one of the enabled conditions occurs the 6500 will assert the SRQ signal. The controller may interrogate the 6500 with Serial Poll (No response is given to Parallel Poll). The 6500 will respond to Serial Poll with a single status byte. The interpretation of each bit in the status byte is shown below.


Bit : 7 6 5 4 3 2 1 0
Decimal value indicates which event caused the SRQ.
Not used (always 0).
1 indicates SRQ asserted by 6500.
Not used (always 0).

The decimal value of bits 0-3 indicates which event caused the SRQ as follows:

0	-	Not used.
1-9	-	Front panel key press (keys 1-9).
10	-	End of sweep.
11	-	Limits exceeded (if limit checking enabled).
12	-	Error encountered.
13	-	Plot menu response awaited.
14	-	Not used.
15	-	Not used.
16	-	Not used.

81. Using the SRQ functions The End-of-Sweep SRQ may be useful in systems where very slow sweep speeds are used. Using the SRQ to indicate a new measurement will allow the controller to perform other tasks during the sweep.

82. Specific error conditions can be checked with the status string as described earlier, but in some situations it may be better to let the 6500 interrupt the controlling program if any error occurs. The program would then check the status string to determine the error number and then take appropriate action.

83. The SRQ on limits exceeded is useful for systems where testing is carried out on a GO/NO-GO basis. The SRQ will only be issued if limit checking is enabled.

84. The key-press SRQ allows program flow to be controlled from the 6500 keyboard. By providing the appropriate service routines up to nine different control program actions or routines can be initiated by pressing the appropriate 6500 key. This facility is useful where the controller is remote from the main measurement system.

85. In order to use the 6500 plot functions under GPIB control it is necessary to use the plot SRQ facility. When PLOT mode is entered with 'P' the 6500 requires a short time to initialise various parameters and provide the option menu. When this has been done the instrument is ready to receive a menu number. Also, the time taken to complete each plot operation and return to the menu depends on the pen speed selected and the type of data being plotted. The plot SRQ facility asserts the SRQ signal whenever the 6500 has displayed a plot menu and is waiting for an option number. Note that this occurs on the menus for pen speed and pen-lift sense selection as well as the main option menu. A controlling program using PLOT mode should provide a routine to wait for the plot SRQ and then return. This routine should be called before sending each plot menu option number.

86. GPIB Program Examples. The following paragraphs contain a selection of sample GPIB routines and programs outlining general use of the 6500 under GPIB control and illustrating some of the specific techniques mentioned above.

GPIB PROGRAMMING EXAMPLES

87. The routines and programs in this section give a general introduction to operating the 6500 over the GPIB. Many of the techniques outlined in Chap. 3-1 (GPIB Operation) are illustrated. The aim of this section is to build a library of utility routines which the user may include as required in system control programs.

88. All the routines are written in BASIC for use on the Hewlett Packard 85 series computers. Each example has an introduction giving details of function, application, input requirements, output variables and subroutine dependencies. Remarks, indicated by !... are used throughout the listings. These may, of course, be omitted from the user's program. Jumps and calls to external routines are indicated by GOTO/GOSUB 9999. The accompanying remark indicates the routine called. For this purpose each routine is assigned a label, although it should be noted that the HP85 computer does not allow the use of labelled subroutines. For convenience all the routines are located at line 1000. In practice, of course, this would not be the case.

89. In order to make translation to other dialects of BASIC (e.g.for Tektronix, Pet etc.) as simple as practicable,BASIC statements unique to the HP85 are avoided where possible.

EXAMPLE 1 - VALDAT

Function: Read 6500 status string and return only when measurement data is valid.

Application: Use before executing any of the following codes:

STA STB STR STC SHSTA SHSTB SHSTR SHSTC FZ P MX MN

Input: A1 - GPIB Address of 6500

Output: S$ - current status string

Sub.Calls: None

```
1000 OUTPUT A1 ;"RS" ! ..... Tell 6500 to output status
1010 ENTER A1 ; S$ ! ..... Read status string
1020 IF S$[5,5]="0" THEN 1000 ! ..... If data not valid loop back
1030 RETURN ! ..... Otherwise return
```

EXAMPLE 2 - AUTOZ

Function: Perform 6500 Auto-Zero operation. Return when completed with error flag.
RF power must be off during the Auto-Zero operation.

Application: Auto-Zero should be performed after power on or Device Clear and when ambient temperature drift is suspected.

Input: A1 - GPIB Address of 6500

Output: E1 - Error flag: 0=Zero successful 1=Zero failed.
S$ - current status string

Sub.Calls: VALDAT (EX.1)

```
1000 OUTPUT A1 ;"SHAR" ! ..... Initiate Auto-Zero
1010 GOSUB 9999 ! ..... Call VALDAT routine (EX.1)
1020 IF S$[1,2]="42" THEN E1=1 ELSE E1=0 ! ..... Set error flag as appropriate
1030 RETURN ! ..... and return
```

EXAMPLE 3 - FREEZE

Function: Place 6500 in FREEZE mode if not already there.

Application: Use FREEZE mode for writing data (see EX.7) or photography.

Input: A1 - GPIB Address of 6500

Output: S$ - current status string

Sub.Calls: VALDAT (EX.1)

```
1000 OUTPUT A1 ;"RS" ! ..... Prepare for status reading
1010 ENTER A1 ; S$ ! ..... Read 6500 status
1020 IF S$[8,8]="1" THEN RETURN ! ..... Return if already in FREEZE
1030 GOSUB 9999 ! ..... Call VALDAT routine (EX.1)
1040 OUTPUT A1 ;"FZ" ! ..... Select FREEZE mode
1050 RETURN ! ..... Return to calling point
```

EXAMPLE 4 - PLTSRQ

Function: Output 6500 PLOT option and wait for SRQ before returning.

Application: Use during hard-copy operations for each PLOT function. Routine assumes 6500 PLOT SRQ enabled.

Input: A1 - GPIB Address of 6500
P$ - PLOT option to execute (P, 0-8)

Output: S - 6500 status byte

Sub.Calls: None

```
1000 ON INTR 7 GOTO 1040 ! ..... HP85 Interrupt vector
1010 OUTPUT A1 ;P$ ! ..... Send PLOT option to 6500
1020 ENABLE INTR 7;8 ! ..... Enable HP85 GPIB interrupts
1030 GOTO 1030 ! ..... Wait for SRQ
1040 STATUS 7,1 ; S ! ..... Reset HP85 interrupt flag
1050 S=SPOLL(A1) ! ..... Fetch 6500 status byte
1060 IF NOT BIT(S,6) THEN 1020 ! ..... Ignore non 6500 interrupts
1070 IF S-64<>13 THEN 1020 ! ..... and everything but PLOT SRQ
1080 OFF INTR 7 ! ..... Disable HP85 vector
1090 RETURN ! ..... Return if correct SRQ received
```

EXAMPLE 5 - PLOT

Function: Plot current displayed trace(s) with labelled axes.

Application: Use to produce hard-copy of any displayed trace(s) on an X-Y plotter. Plotter bottom left/top right must be set. All 6500 SRQ functions are disabled on exit.

Input:
A1 - GPIB Address of 6500
P - Plot speed required (1-9)

Output:
S - 6500 status byte
S$ - Current status string
P$ used for plot options

Sub.Calls:
VALDAT (EX.1)
PLTSRQ (EX.4)

```
1000 GOSUB 9999 ! ..... Call VALDAT routine (EX.1)
1010 OUTPUT A1 ;"SQ00001" ! ..... Enable PLOT SRQ
1020 P$="P" ! ..... First task is to enter PLOT
1030 GOSUB 9999 ! ..... Call PLTSRQ routine (EX.4)
1040 P$="S" ! ..... Select plot speed option
1050 GOSUB 9999 ! ..... Call PLTSRQ routine (EX.4)
1060 P$=VAL$(P) ! ..... Plot speed number
1070 GOSUB 9999 ! ..... Call PLTSRQ routine (EX.4)
1080 FOR I=4 TO 6 ! ..... PLOT loop (AXES, LABELS, PLOT
1090 P$=VAL$(I) ! ..... Set option number
1100 GOSUB 9999 ! ..... Call PLTSRQ routine (EX.4)
1110 NEXT I ! ..... Repeat for options 4,5,6
1120 OUTPUT A1 ;"SQ00000" ! ..... Disable all 6500 SRQ function
1130 OUTPUT A1 ;"N" ! ..... Restore NORMAL sweep
1140 RETURN ! ..... and return
```

EXAMPLE 6 - AREAD

Function: Read channel A trace into an array (A) with 422 elements (0-421). Note that channel A need not be displayed for this operation.

Application: Data in the array may be used in mathematical processing or saved on a magnetic storage medium.

Input:
A1 - GPIB Address of 6500

Output:
A() - Amplitude data for 422 points across channel A trace.
G1 - Start frequency (GHz)
G2 - Stop frequency (GHz)
S$ - Current status string
I - Used internally as loop counter

Sub.Calls: None

```
1000 OUTPUT A1 ;"BP0E RF" ! ..... Set B/L to 0 for Fstart value
1010 ENTER A1 ; G1 ! ..... Read start frequency
1020 G1=G1/1000000000 ! ..... Convert to GHz
1030 OUTPUT A1 ;"BP421E RF" ! ..... Set B/L to 421 for Fstop value
1040 ENTER A1 ; G2 ! ..... Read stop frequency
1050 G2=G2/1000000000 ! ..... Convert to GHz
1060 FOR I=0 TO 421 ! ..... Set up trace reading loop
1070 OUTPUT A1 ;"BP";I;"E RA" ! ..... Position B/L for reading
1080 ENTER A1 ; A(I) ! ..... Read amplitude into array
1090 NEXT I ! ..... repeat 422 times
1100 RETURN ! ..... Return to calling point
```

EXAMPLE 7 - AWRITE

Function: Set start/stop frequencies to G1/G2 values then write data in array A to channel A display and store in memory A.
The routine assumes that G1/G2 are within the current F1/F2 values.

Application: Use this routine to create a reference trace. The data in array A may be calculated or previously read from the 6500 using AREAD (EX.6).

Input:
A1 - GPIB Address of 6500
G1 - Start frequency (GHz)
G2 - Stop frequency (GHz)
A()- 422 element array containing amplitude data.

Output:
S$ - Current status string
I - Used internally as loop counter

Sub.Calls: FREEZE (EX.3)

```
1000 OUTPUT A1 ;"CA" ! ..... Select channel A
1010 OUTPUT A1 ;"SS";G1;"E SP";G2;"E" ! ..... Set start/stop frequencies
1020 GOSUB 9999 ! ..... Call FREEZE routine (EX.3)
1030 FOR I=0 TO 421 ! ..... Set up data write loop
1040 OUTPUT A1 ;"BP";I;"E" ! ..... Set B/L position for write
1050 OUTPUT A1 ;"WD";A(I);"E" ! ..... Write data
1060 NEXT I ! ..... Repeat 422 times
1070 OUTPUT A1 ;"STA" ! ..... Store trace in memory A
1080 OUTPUT A1 ;"N" ! ..... Restore 6500 to NORMAL sweep
1090 RETURN ! ..... Return to calling point
```

EXAMPLE 8 - SYNTH

Function: Display auto-ranged sweep using 6800 synthesizer. Return in FREEZE mode.

Application: Use when synthesizer accuracy required. Routine returns after the first displayed sweep but could alternatively continue sweeping. Fast lock-up time of 6800 allows operation at full bus speed.

Input:
A1 - GPIB Address of 6500
A2 - GPIB Address of 6800
G1 - Start frequency (GHz)
G2 - Stop frequency (GHz)
Note: G1/G2 assumed to be within current F1/F2 limits and 6800 range.

Output:
F - used internally for frequency calculation
S,I - used internally as loop counters

Sub.Calls: None

```
1000 OUTPUT A1 ;"SS";G1;"E" ! ..... Set 6500 start (display only
1010 OUTPUT A1 ;"SP";G2;"E" ! ..... Set 6500 stop (display only)
1020 OUTPUT A1 ;"SH2" ! ..... Select synthesiser mode
1030 OUTPUT A1 ;"AR" ! ..... Initiate auto-range
1040 FOR S=1 TO 2 ! ..... 2 sweeps required for auto-r
1050 FOR I=0 TO 421 ! ..... 422 steps in each sweep
1060 F=G1+I*(G2-G1)/421 ! ..... Calculate synthesiser freque
1070 F=INT(F*100000+.5) ! ..... Round to units of 10kHz
1080 OUTPUT A2 ;"F";F ! ..... Send frequency to synthesise
1090 OUTPUT A1 ;"SH3" ! ..... Step 6500 to next position
1100 NEXT I ! ..... Next increment loop
1110 NEXT S ! ..... Next sweep loop
1120 OUTPUT A1 ;"FZ" ! ..... Send 6500 to FREEZE mode
1130 RETURN ! ..... and return
```

EXAMPLE 9 - MAXMIN

Function: Return amplitude and frequency values of max/min points on trace A and place markers on display.

Application: Use instead of limit checking and to find maximum excursion of trace.

Input: A1 - GPIB Address of 6500

Output:
P1 - Amplitude at max point (current units)
P2 - Amplitude at min point (current units)
G1 - Frequency at max point (GHz)
G2 - Frequency at min point (GHz)

Sub.Calls: VALDAT (EX.1)

```
1000 GOSUB 9999 ! ..... Call VALDAT routine (EX.1)
1010 OUTPUT A1 ;"MX MK RA" ! ..... Set max brightline/marker/read
1020 ENTER A1 ; P1 ! ..... Read max amplitude
1030 OUTPUT A1 ;"RF" ! ..... Initiate frequency read
1040 ENTER A1 ; G1 ! ..... Read frequency at max point
1050 G1=G1/1000000000 ! ..... Convert to GHz
1060 OUTPUT A1 ;"MN MK RA" ! ..... Set min brightline/marker/read
1070 ENTER A1 ; P2 ! ..... Read min amplitude
1080 OUTPUT A1 ;"RF" ! ..... Initiate frequency read
1090 ENTER A1 ; G2 ! ..... Read frequency at min point
1100 G2=G2/1000000000 ! ..... Convert to GHz
1110 RETURN ! ..... Return to calling point
```

EXAMPLE 10 - EXPAND

Function: Find max point on current full width trace and select symmetrical sweep with specified width.

Application: Use to examine trace peak. If DF sweep would exceed current F1/F2 limits then routine returns with error flag set.

Input:
- A1 - GPIB Address of 6500
- F - Required sweep width

Output:
- E1 - error flag 0=task accomplished 1 = sweep out of range
- F1 - Sweeper F1 (GHz)
- F2 - Sweeper F (GHz)
- F3 - DF centre frequency (GHz)

Sub.Calls: VALDAT (EX.1)

```
1000 OUTPUT A1 ;"FW" ! ..... Select full width (F1-F2) sweep
1010 OUTPUT A1 ;"BP0E RF" ! ..... Set B/L to 0 for freq. read
1020 ENTER A1 ; F1 ! ..... Read F1
1030 F1=F1/1000000000 ! ..... Convert to GHz
1040 OUTPUT A1 ;"BP421E RF" ! ..... Set B/L to 421 for freq.read
1050 ENTER A1 ; F2 ! ..... Read F2
1060 F2=F2/1000000000 ! ..... Convert to GHz
1070 GOSUB 9999 ! ..... Call VALDAT routine (EX.1)
1080 OUTPUT A1 ;"MX RF" ! ..... Set B/L to max for freq.read
1090 ENTER A1 ; F3 ! ..... Read freqency at max point
1100 F3=F3/1000000000 ! ..... Convert to GHz
1110 IF F3-F/2(F1 OR F3+F/2)F2 THEN E1=1 @ RETURN ! ..... Check freq. and return on error
1120 E1=0 ! ..... Reset error flag
1130 OUTPUT A1 ;"DF";F;"E" ! ..... Set DF mode
1140 OUTPUT A1 ;"AR" ! ..... Auto-range new display
1150 RETURN ! ..... and return
```

EXAMPLE 11 - SETCNT

Function: Set 6500 F1/F2 values using a frequency counter.

Application: Use when greater accuracy than sweeper scale is required. The routine assumes that sweeper output is connected to a GPIB counter which outputs frequency in Hz. Settling delay times may be altered to suit sweeper and counter used.

Input: A1 - GPIB Address of 6500
A2 - GPIB Address of frequency counter

Output: F1 - Sweeper minimum (GHz)
F2 - Sweeper maximum (GHz)

Sub.Calls: None

```
1000 OUTPUT A1 ;"SHSS" ! ..... Send ramp to min for F1 entr
1010 WAIT 500 ! ..... 500ms settling delay
1020 ENTER A2 ; F1 ! ..... Read counter frequency
1030 F1=F1/1000000000 ! ..... Convert to GHz
1040 OUTPUT A1 ;F1 ! ..... Send value to 6500
1050 OUTPUT A1 ;"SHSP" ! ..... Send ramp to max for F2 entr
1060 WAIT 500 ! ..... 500ms settling delay
1070 ENTER A2 ; F2 ! ..... Read counter frequency
1080 F2=F2/1000000000 ! ..... Convert to GHz
1090 OUTPUT A1 ;F2 ! ..... Send value to 6500
1100 RETURN ! ..... Return to calling point
```

EXAMPLE 12 - FINDFW

Function: Find current F1/F2 and Start/Stop frequencies and return with Start/Stop frequencies unchanged.

Application: Use when F1/F3 values are not known.

Input: A1 - GPIB Address of 6500

Output:
F1 - current F1 value (GHz)
F2 - current F2 value (GHz)
G1 - Current Fstart value (GHz)
G2 - Current Fstop value (GHz)

Sub.Calls: None

```
1000 GOSUB 1070 ! ..... Read Fstart/Fstop frequencies
1010 G1=F1 @ G2=F2 ! ..... Place in Fstart/Fstop variables
1020 OUTPUT A1 ;"FW" ! ..... Set to Full Width sweep
1030 GOSUB 1070 ! ..... Read F1/F2 frequencies
1040 OUTPUT A1 ;"SS";G1;"E SP";G2;"E" ! ..... Restore Fstart/Fstop sweep
1050 RETURN ! ..... and return
1060 ! ..... Subroutine to read frequencies
1070 OUTPUT A1 ;"BP0E RF" ! ..... Set B/L to 0 for freq. read
1080 ENTER A1 ; F1 ! ..... Read minimum frequency
1090 F1=F1/1000000000 ! ..... Convert to GHz
1100 OUTPUT A1 ;"BP421E RF" ! ..... Set B/L to 421 for freq. read
1110 ENTER A1 ; F2 ! ..... Read maximum frequency
1120 F2=F2/1000000000 ! ..... Convert to GHz
1130 RETURN ! ..... Return to main routine
```

EXAMPLE 13 - BLPOS

Function: Position brightline at specified frequency providing that frequency is within current Fstart/Fstop values.

Application: Use to position brightline at nearest position to desired frequency.

Input:
- A1 - GPIB Address of 6500
- F - Frequency required (GHz)

Output:
- F1 - Current Fstart value (GHz)
- F2 - Current Fstop value (GHz)
- P - Brightline position
- E1 - Error flag 0=successfull 1=Frequency outside Fstart/Fstop range.

Sub.Calls: None

```
1000 OUTPUT A1 ;"BP0E RF" ! ..... Set B/L to 0 for freq. read
1010 ENTER A1 ; F1 ! ..... Read Fstart frequency
1020 F1=F1/1000000000 ! ..... Convert to GHz
1030 OUTPUT A1 ;"BP421E RF" ! ..... Set B/L to 421 for freq. read
1040 ENTER A1 ; F2 ! ..... Read Fstop frequency
1050 F2=F2/1000000000 ! ..... Convert to GHz
1060 IF F<F1 OR F>F2 THEN E1=1 @ RETURN ELSE E1=0 ! ..... Check F and return if error
1070 P=INT((F-F1)*((F2-F1)/421)+.5) ! ..... Calculate nearest B/L position
1080 OUTPUT A1 ;"BP";P;"E" ! ..... and set B/L accordingly
1090 RETURN ! ..... Return to calling point
```

EXAMPLE 14 - SYMSWP

Function: Set symmetrical sweep with specified centre and width providing this is within the current F1/F2 values.

Application: Allows set up of symmetrical sweep without knowing required brightline position for centre frequency.

Input:
A1 - GPIB Address of 6500
F - Required centre frequency (GHz)
W - Required sweep width (GHz)

Output:
F1 - Current F1 value (GHz)
F2 - Current F2 value (GHz)
G1 - Previous Fstart value (GHz)
G2 - Previous Fstop value (GHz)
P - Brightline position
E1 - Error flag 0=successfull 1=sweep outside F1/F2 range

Sub.Calls: FINDFW (EX.12)
BLPOS (EX.13)

```
1000 E1=0 ! ..... Initialise error flag
1010 GOSUB 9999 ! ..... Call FINDFW routine (EX.12
1020 IF F+W/2>F2 OR F-W/2<F1 THEN E1=1 @ RETURN ! ..... Return if sweep not possib
1030 OUTPUT A1 ;"FW" ! ..... Set Full Width sweep
1040 GOSUB 9999 ! ..... Call BLPOS routine (EX.13)
1050 OUTPUT A1 ;"DF";W;"E" ! ..... Set up symmetrical sweep
1060 RETURN ! ..... and return
```

Chapter 3-2

APPLICATIONS

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APPLICATIONS OF 6500

Introduction

1. The concept of swept frequency response testing is well established as a measurement technique. The versatility of 6500 enables a wide variety of microwave measurements to be made, without recourse to "pencilled" reference marks and without the need to establish reference offsets in dB ratio loss/gain measurements; in fact 6500 measures and displays absolute power. In addition the display provides all the information necessary to identify frequency, amplitude, out of limit operation, etc for the particular measurement.

The display, using on-screen graphics and the unique PLOT facility enables easy interpretation and recording of results.

Measurements that can be made using 6500 fall into 5 main categories:

Absolute power vs. Frequency

Transmission loss or gain vs.Frequency

Return loss vs. Frequency

Power output or gain vs.Power input

Comparison or ratio measurements

2. The 6500 provides a ramp output voltage which is used to tune an r.f. source requiring either a fixed 0 - 10V input or a variable 0 - 20V input. Some r.f. sources may need adaptors to access this external drive (e.g. 8620C series sweepers from Hewlett Packard). Others may need minor changes to enable the external drive (e.g.6600 series Sweepers from Wiltron require the top cover to be removed and the EXT SWP switch turned on). In case of doubt refer to r.f.source manufacturer's instructions.

On multiband sweepers it may be necessary to use the SYNC input to 6500 to create a dwell during the sweep ramp to allow for the time delay as oscillators covering different parts of the band are switched in and out. If this is not done, small break lines may appear in the 6500 display at band switch points. Ensure that any amplitude modulation (e.g. 1 kHz) is switched off.

Initialization of sweeper

3. Initialization of the system is common to all measurements with 6500. This falls into two areas:

i) Zeroing of the detectors.

ii) Alignment of frequency coverage with 6500 display.

The first must be made with the 6510 series detectors connected to the instrument and the r.f. source turned off.

Press

6500 holds up the sweep while the build up of d.c. voltages in the probes and front end circuitry are nulled. The display shows when this operation is completed. Note that the Autozero Status Message is automatically erased at the end of the ZERO operation if all three channels zero satisfactorily. If the result is not as shown, refer to Chap. 3-1, paras. 35 to 38.

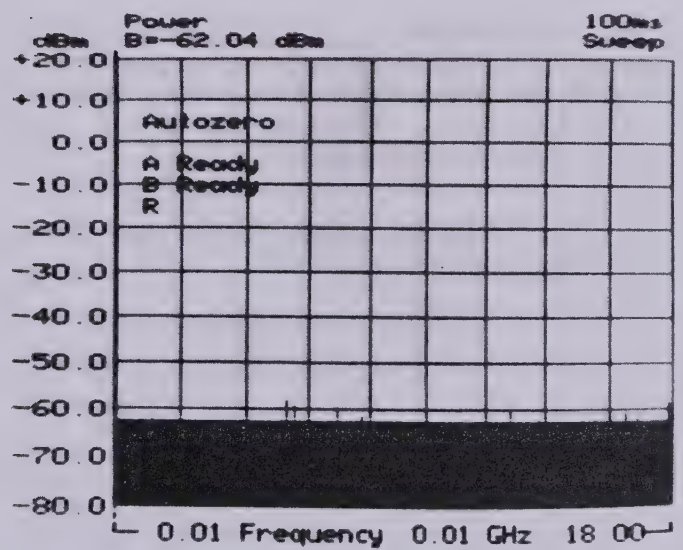


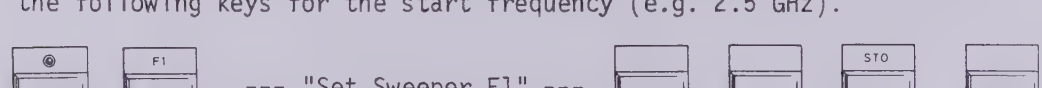
Fig. 1 Auto zero status message

4. The second initialization is to ensure that the 6500 frequency display aligns with the r.f. source coverage. The procedure is as follows:-

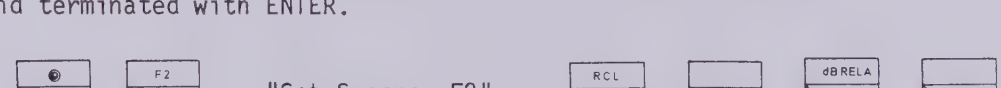
Press SHIFT and F1, the ramp will now be at minimum. Adjust the offset control on the 6500 for the specified lower external drive level of the r.f. source.

Press SHIFT and F2, the ramp is now at maximum. Use a small screwdriver to adjust coarse and fine controls on the 6500 rear panel to the specified higher external drive level of the r.f. source.

Connect up ramp input to r.f. source and sync if necessary and press the following keys for the start frequency (e.g. 2.5 GHz).



This sets the ramp voltage to zero or its lower level. This frequency may be read off a microwave counter or the sweeper display value used. The GHz values are entered via the key pad to a resolution of 10 MHz and terminated with ENTER.

5. 

The above procedure is carried out to set the higher level of ramp, pressing SHIFT and F2 keys to obtain the prompt, after this enter the measured r.f. source frequency (e.g. 6.8 GHz) and terminate with the ENTER key.

NOTE...

The following applications assume that the above procedures have been carried out.

Absolute power measurements

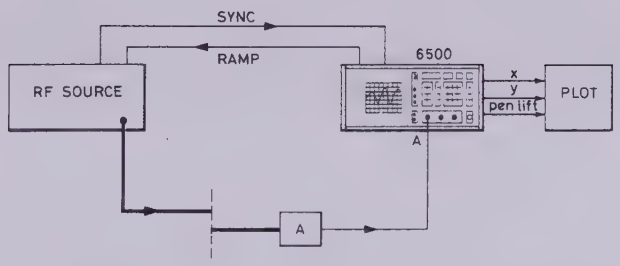


Fig. 2 Absolute power measurements, interconnecting diagram

6. 6500 will display the absolute power output of the r.f. source. The maximum and minimum values can be read using the BRIGHTLINE controls and the variation in power easily noted. Particular areas of interest in the swept power performance can be examined by using the BRIGHTLINE and

keys to change the displayed frequency range. The 6500 will display the power directly in mW on a scale 0 - 50 mW by depressing

key. The set up could also be used for checking the variation in power of solid state microwave oscillators such as varactor tuned Gunn and f.e.t. Oscillators using a linearizer if necessary. However the linearity of the frequency display would be no better than the linearity of tuning of the oscillator.

Measurement of Insertion Loss

7. The arrangement of Fig. 2 could be used for measurement of loss or gai of a device by inserting it between the r.f. source and the detector. A calibration run is first performed to store into memory A the sweeper characteristic power variation. Then with the device inserted the display is changed to subtract the memory values from current values. This technique can suffer from two principle problems :

1. RF source performance may vary with time.

2. RF source performance may vary with load.

8. To overcome these problems a Reference channel is provided to monitor r.f. source performance. This is shown in Fig. 3 where a power splitter is used on the r.f. source output with the Reference channel detector connected to one arm.

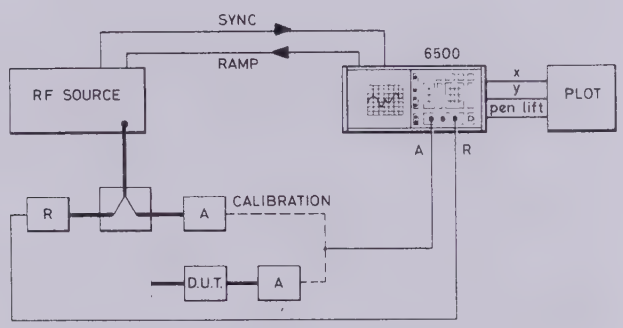


Fig. 3 Insertion loss measurement, interconnecting diagram

The system carries a 6 dB penalty in dynamic range due to the loss through the splitter. If this is unacceptable a directional coupler may be preferred.

9. The isolation of power splitters is not as good as high directivity couplers and reflected signals incident on R can give rise to errors. Measurements may now be made firstly with a calibration run A-R and stored to memory A, then with the device inserted, A-R is displayed with subtraction of memory A.

10. This technique still needs to be examined with caution, since r.f. source harmonics will add to the power measured by the detectors and, depending on the phase, and depending on the characteristics of the device under test, give significant errors. RF source harmonics should be 40 dB down on the carrier. The accuracy of the 6500 with 6510 series detectors is highest in the region of 0 dBm, and although 6510 series detectors' square-law deviation is corrected by the 6500, the errors increase as incident power increases. Hence measurements should ideally be made with incident power levels between +10 and -40 dBm. If sweeper harmonics are higher than -40 dBc, a low pass filter should be included in the output circuit, though this may limit useful measurements to octave-band frequency

ranges. To preserve a good source match a padding attenuator may be needed between the filter and the power splitter/coupler. The coupler should be of high directivity, again to provide a good source match.

11. The full front panel keyboard facility of 6500 may be used to speed up measurements, for example transmission loss or gain through a device - see Fig. 3. With detectors and any adaptors connected to the two arms of the power splitter or coupler select the following keys:-

Without device under test :

Normalize display :

Insert device under test. Use AUTO if required to obtain best fit of the trace on the screen.

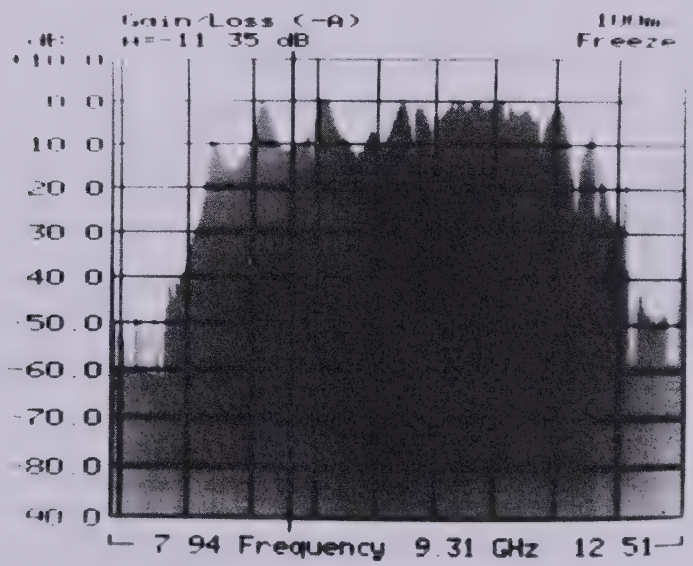


Fig. 4 Insertion loss measurement display (without using Reference)

Measurement of return loss

12. Return loss or v.s.w.r. of a device may be measured using a high directivity coupler or bridge to provide a sample of the reflected power. The comments in paragraphs 8 and 9 concerning the use of the reference channel, the need for low source harmonics and the need for a good source match are equally applicable for accurate measurements.

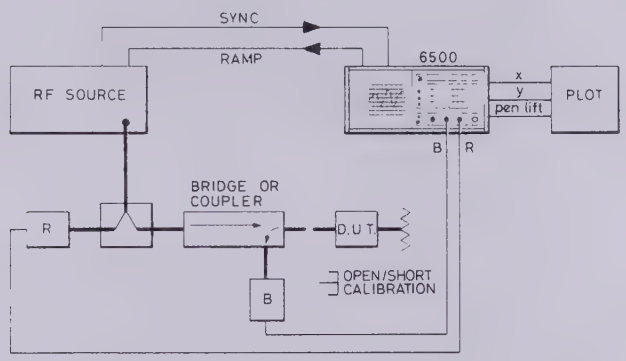


Fig. 5 Return loss measurements, interconnecting diagram

To provide a calibration for return loss or v.s.w.r. measurements the averaged value of reflections from an open circuit and a short circuit over the frequency band of interest is stored in memory B.

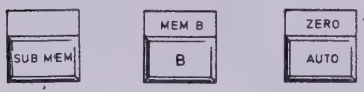
13. The Reference channel, as before, is subtracted from each display to remove variation of the r.f. source. When the unit under test is connected to the test port the resultant return loss is displayed by subtracting R and subtracting memory B. This return loss may be viewed directly as a v.s.w.r. on a scale up to 3:1 by pressing the UNITS key.

If the device under test is a one port device the above procedure is adequate bearing in mind the sources of error due to source match, detector variations and 6500 channel accuracy. However if the unit under test is a multiport device, the remaining ports should be properly terminated.

14. A microwave bridge usually has an insertion loss of about 6 dB and this may limit the effective dynamic range, particularly since the power handling may be limited. A coax wideband coupler, however, generally has a narrower frequency range with reduced insertion loss and higher power handling capability. With open circuit termination to bridge or coupler, store the response in memory B by selecting the following keys:-

Replace open circuit by short circuit and then select SHIFT, STORE AV, and B channel keys:-

This stores the average of the open and short circuit reflections in Memory B without the effect of sweeper variations. Insert device under test, properly terminated if necessary, and select the following keys:-



The display now shows the return loss of the device in dB.

To convert to v.s.w.r. press the UNITS key.

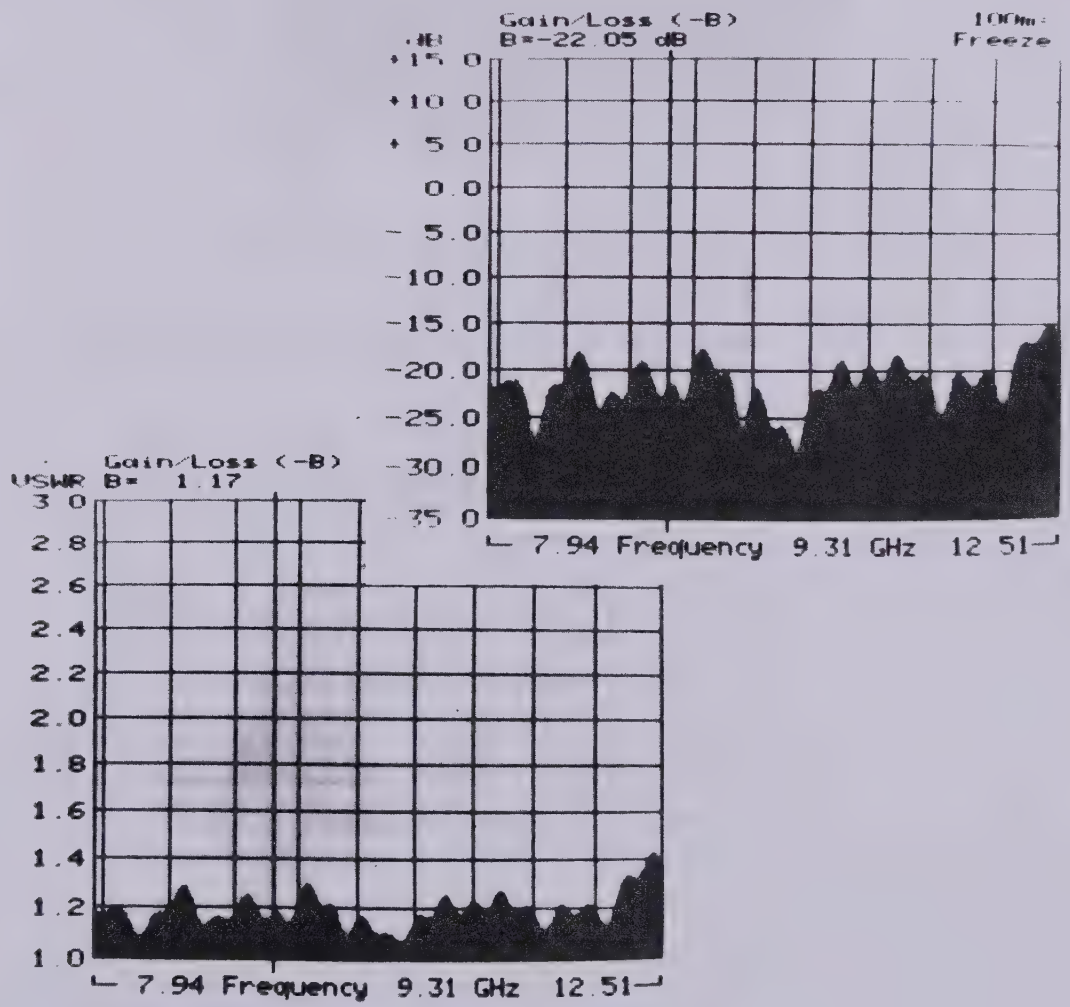


Fig. 6 Return loss measurement display (without using Reference)

Simultaneous return loss and transmission loss

15. The procedure follows paragraphs 12 to 14 above in that channel A detector senses the transmitted signal, channel B the return loss signal, and channel R is used for reference to normalize the response. Open and short circuit calibration data is stored in Memory B and subtracted from the display on channel B once the unit under test is inserted e.g. Connect detector A to measurement plane.

Measure power at A subtracting reference channel and store in Memory A

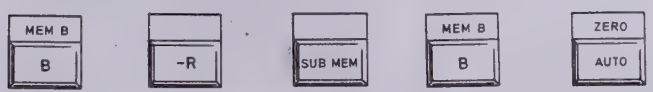
Remove detector A and follow procedure for open and short circuit calibration.

Open circuit:

Short circuit:

Remove the short circuit and insert the device under test:

For Return Loss:



For Transmission Loss:

Both may be viewed by pressing the following keys:-

The results are shown illustrated in Fig. 7.

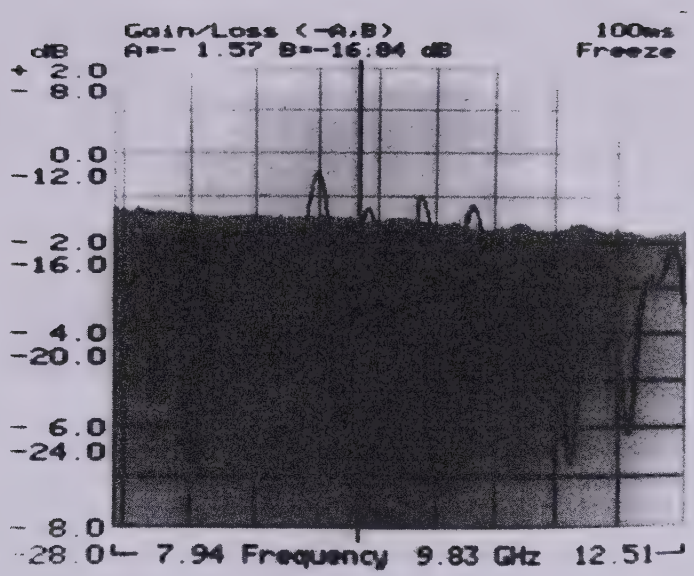


Fig. 7 Simultaneous return loss and transmission loss display (without using Reference)

Waveguide measurements

16. Using similar high directivity couplers (>40 dB), return loss and transmission loss measurements may be made in waveguide systems using the arrangement shown in Fig. 8. The 6511 or 6512 detectors are coupled to the system through coax to waveguide transformers.

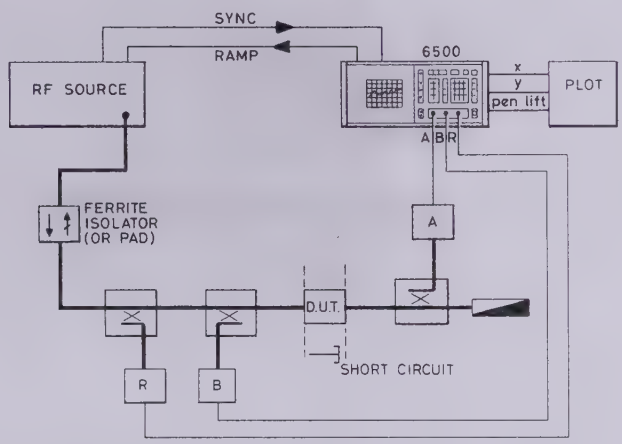


Fig. 8 Waveguide measurements, interconnecting diagram

17. Calibration is made using a waveguide short circuit. The device under test is then inserted at the measurement port and the display shows return loss when the reflection due to the short circuit is subtracted.

18. The signal transmitted through the device under test is sensed by detector A which is connected either directly to the device via a transformer or through a 3rd waveguide coupler. This improves the match seen by the test device but is not necessary from the point of compensating for coupler variation as 6500 memory capability can calibrate the through line. Low v.s.w.r. coax to waveguide transformers must be used to reduce measurement uncertainty.

Using the arrangement shown in Fig. 8:

(1) Establish reference data for channel A by connecting to measurement port select:-

(2) Establish reference data for reflection on channel B by substituting short circuit at measurement port.

(3) Remove short circuit and insert the device under test. Return loss may then be measured by subtracting memory B from B-R and transmission loss measured by subtracting memory A from A-R.

Amplifier 1 dB compression point measurements

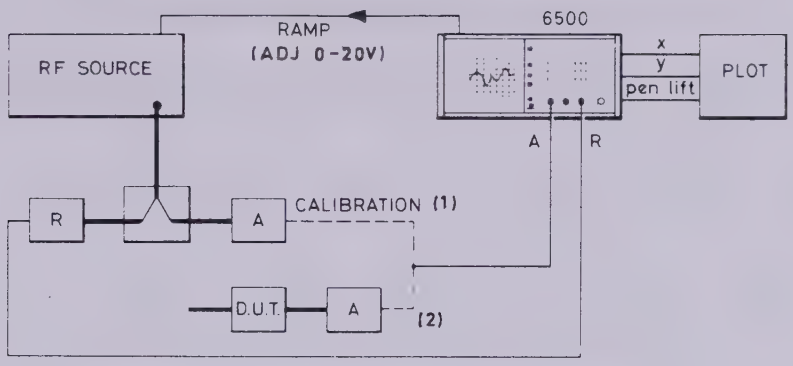


Fig. 9 Amplifier 1 dB compression point measurements

19. This technique uses a ratio between input and output powers followed by a relative output power measurement also including frequency normalization.

(1) With the equipment set up as shown in Fig. 9 connect channel A detector to the power splitter (1) and ensure that the amplifier is operating in its linear region.

(2) Carry out a ratio measurement selecting A and -R.

(3) Normalize the frequency response by selecting:-

(4) Insert the amplifier (D.U.T.) connecting this and channel A detector as shown in Fig. 9 step (2).

Note. If the amplifier has an output level greater than +16 dBm, a suitable attenuator pad should be inserted before the detector.

(5) Measure the amplifier gain as follows:-

(6) Select a reference point on the display with the brightline control and reference this point to 00.00 dB selecting:-

(7) Set DATUM to +1 dB, set RANGE to 1 dB/div. Increase the r.f. source level until the response at the reference point falls by 1 dB, this indicates the 1 dB compression point.

(8) The actual amplifier output power at this frequency can be measured by selecting channel A

and reading power at the brightline frequency.

Note. If an attenuator was included before channel A detector - its value at the brightline frequency chosen as a reference - must be added to the power measured.

Comparison of device performance against a stored reference

20. There are occasions when the gain or loss of an unknown or test devic such as a filter or amplifier needs to be compared with that of a reference device. One technique is as follows (use of channel R is omitted for clarity):-

(1) With detector A connected to the r.f. source select:-

This serves as a calibration and normalization procedure.

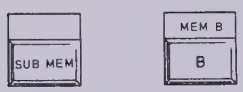
(2) Insert "standard" device between r.f. source and detector A and select

to display response of "standard" device.

(3) This "standard" response is now stored in memory B by selecting

(4) Without detector B connected to channel B input select:-

The display shows B channel at its lowest level without the noise contribution of detector B. Select:-



This subtracts the "standard" trace from the low level in B and it is then re-written into memory B by selecting:-

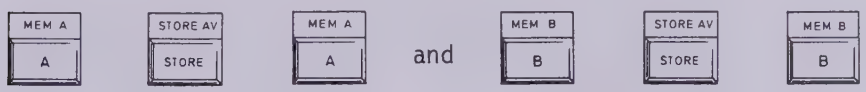
(5) The test device is now substituted for the "standard" device and displayed as a line by selecting:-

(6) Finally to compare and display the stored "reference" as a histogram and the current test performance as a line in a normalized form select:-

Measurements of gain/loss tracking between similar devices

21. This technique can be used to examine the differential gain or loss between for example matched amplifiers or attenuators. After initialization the procedure is as follows:

(1) Normalize for systems errors by connecting A and B detectors to both arms of a power splitter fed from the r.f. source and select:-



(2) The two test devices are then inserted in the lines between the splitter arms and the detectors. One device (e.g. that on Channel A) is then normalized and stored in memory R by selecting:-

(3) The other channel is now normalized and the performance of the other device subtracted by selecting:-

This display now shows the difference between the two devices.

Control of graticule lines

22. Vertical graticule lines may be re-instated at sweep widths less than 0.1 GHz. Three methods of achieving this are shown in the following paragraphs.

23. Scaling factor method.

(1) Select SHIFT and F2 (F2 is selected to avoid 'error' prompts when entering a number where F1 > F2)

---"Set Sweeper F2"---

(2) Measure r.f. source output frequency with a frequency counter.

(3) Enter this value directly by the keyboard, keeping the resolution required, e.g. 52.47 MHz.

Normal entry :	0.05 GHz
x10 Resolution :	0.52 GHz
x100 Resolution :	5.24 GHz
x1000 Resolution :	52.47 GHz

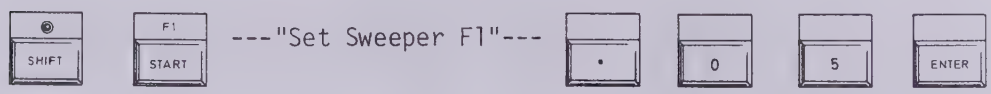
(4) Repeat the procedure for F1.

(5) Note that with F2-F1 difference greater than 0.1 GHz, vertical graticule lines will be present.

(6) The display readout must be scaled down by the factor chosen.

24. Counter method.

(1) Select SHIFT and F1. Enter frequency information in the normal manner e.g. 50 MHz as 0.05 GHz.



(2) Select SHIFT and F2 (MHz) normally in GHz. Graticule lines may not now be present.

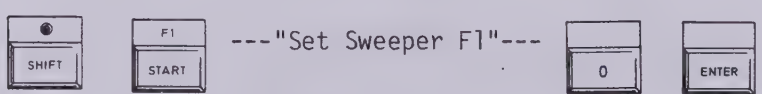
(3) To identify a frequency on the display, connect a frequency counter permanently to the r.f. source output. Then select FREEZE.

--- The brightline control is now linked to the ramp output of the manual frequency control. At any point on the display the the frequency may be read directly from the counter by varying the brightline control.

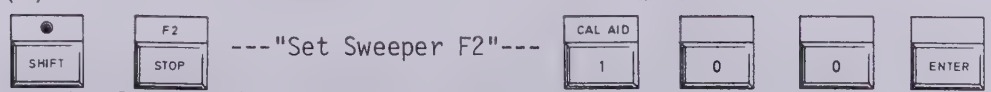
(4) If required up to eight markers can then be placed on the screen at frequencies of interest whilst in this mode by pressing the MARKER key.

25. Ten division graticule method.

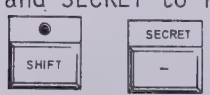
(1) Select SHIFT and F1. Enter F1 as 0.0 GHz.



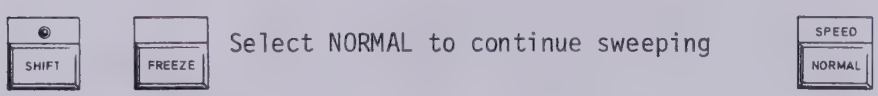
(2) Select SHIFT and F2. Enter F2 as 100 GHz.



The display now divides into 10 equally spaced vertical graticules. Because the display shows 0 to 100 GHz frequency range, select SHIFT and SECRET to remove the erroneous frequency information



(3) To read frequency information from the display, connect a counter to the r.f. source output. Select SHIFT and FREEZE and the frequency at the brightline point can be read to the required resolution.



Broadband frequency response using a frequency window

26. The following procedures define two methods of broadband frequency response measurement using a "fixed window" or Δf for examination of response slopes prior to gain equalization.

27. Sweep generator method.

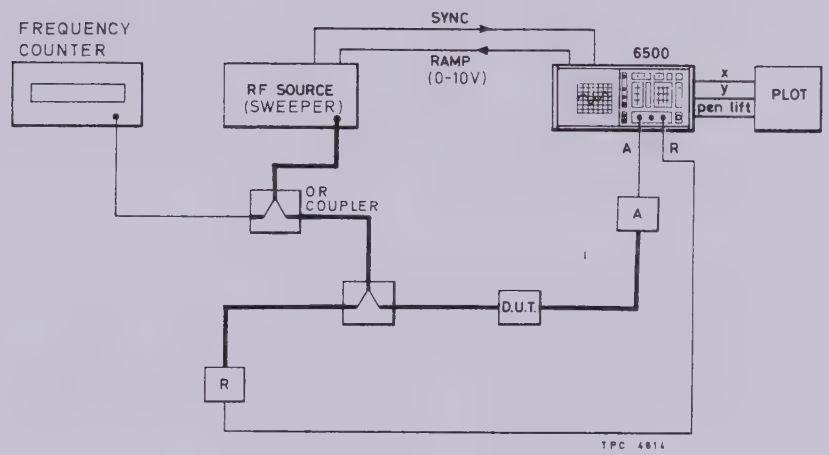
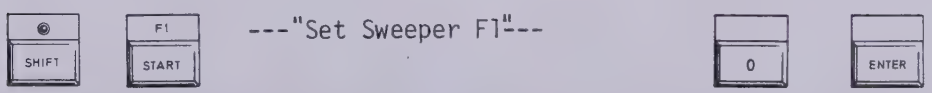


Fig. 10 Broadband measurements using a frequency window, interconnecting diagram

Connect up the equipment as shown in Fig. 10 and set the r.f. source to EXTERNAL operation, connect the 6500 0-10 V FIXED RAMP output to the EXT INPUT of the r.f. source and the frequency counter to one arm of the power divider or coupler.

(1) Set the r.f. source CW control to the lowest frequency of interest and select the Δf facility.

(2) Select SHIFT and F1 on the 6500, note the counter reading and adjust the CW control until the desired lowest frequency is displayed. Enter 0 on the keyboard.



(3) Select SHIFT and F2 on the 6500, note the counter reading and adjust the r.f. source Δf control until the counter reads the incremental frequency shift required. Enter 100 on the keyboard and the equally spaced graticules are now generated

Select SHIFT and SECRET to erase the

frequency information written to the screen and the Δf sweep is now calibrated.

(4) With the measurement detector on channel A connected to the output of the system and the reference detector R, the ratio of the input to output can be displayed and measured on the 6500.

(5) The DATUM and RANGE may be reset to give values within the test specification or alternatively AUTO RANGE may be used to optimize the DATUM and RANGE settings.

(6) By operating MAX and MIN keys, the amplitude values at these points can be measured and the difference in frequency slope measured.

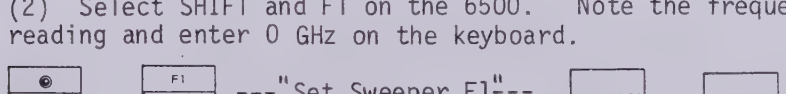
(7) To measure response slopes at any other window position, simply var the CW control of the sweeper and the display will show the frequency response of the system passing through the "fixed window". Measurement are repeated as above.

28. Voltage tunable oscillator method.

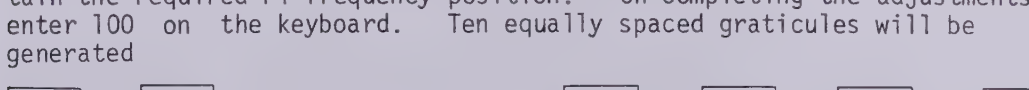
Connect up the equipment as shown in Fig. 10 substituting a voltage tunable oscillator (VTO) for the sweeper r.f. source. Select FM operation on the voltage tunable oscillators and connect the 0-20 V VARIABLE RAMP output to the external FM input of the VTO, (caution : check that maximum accept able f.m. input level is not exceeded).

(1) Set the VTO CW control to the lowest frequency of interest using the frequency counter.

(2) Select SHIFT and F1 on the 6500. Note the frequency counter reading and enter 0 GHz on the keyboard.



(3) Select SHIFT and F2 on the 6500. Adjust the VTO CW control to giv the required incremental frequency shift as shown on the frequency count and adjust COARSE (C) and FINE (F) RAMP, 6500 rear panel controls to giv the desired incremental frequency display. Re-adjust VTO, C and F controls and also if necessary the 6500 rear panel OFF SET control to maintain the required F1 frequency position. On completing the adjustments enter 100 on the keyboard. Ten equally spaced graticules will be generated



(4) Select SHIFT and SECRET to erase the erroneous frequency informatio written to the screen. The "fixed window" or Δf is now calibrated and measurements outlined in para. 25 may be carried out.

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